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TITLE: BONDING MATERIAL AND BONDING METHOD OF ELECTRIC ELEMENT

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ABSTRACT:

PURPOSE: To join a semiconductor element to a pedestral with a sufficient adhesion and a stable electric connection.

CONSTITUTION: An Ni layer 10 and an Au-Sn solder layer 11 are formed on an N-type electrode 9 as the ohmic electrode of a semiconductor laser element. The solder layer 11 is fused and bonded to a heat sink 21 plated with gold 21a. The thickness of the Ni layer 10 is 500Å or greater. At the time of fusion of the solder layer 11, Ni in the Ni layer 10 diffuses in the solder layer 11, and Sn in the solder layer 11 diffuses in the Ni layer 10. As the

result of mutual diffusion, the adhesion and the wettability can be improved. The composition ratio of the Ni layer 10 is set higher than or equal to 1.3wt.% and lower than 10wt.% to the Au-Sn solder layer 11. Thereby bonding is enabled at a low melting point and high bonding strength can be obtained.

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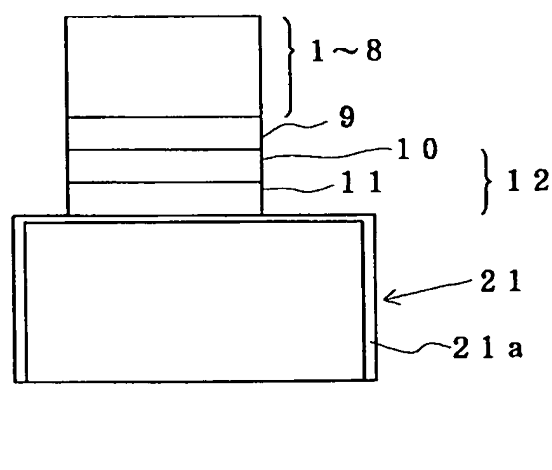
(54)【発明の名称】　電気素子の接合材料および接合方法

(57)【要約】

【目的】　十分な接着強度と安定した電気的接続を得るように半導体素子を台座に接合する。

【構成】　半導体レーザ素子のオーミック電極であるｎ型電極９にＮｉ層１０、Ａｕ－Ｓｎはんだ層１１を形成し、さらにこのはんだ層１１を溶融して、金メッキ２１ａが施されたヒートシンク２１に接合する。Ｎｉ層１０の膜厚としては５００Å以上とする。はんだ層１１の溶融時に、Ｎｉ層１０中のＮｉがはんだ層１１に拡散し、はんだ層１１中のＳｎがＮｉ層１０中に拡散するという相互拡散により、密着強度、塗れ性を向上させることができる。また、Ｎｉ層１０の組成比をＡｕ－Ｓｎはんだ層１１に対し１．３wt%以上１０wt%未満とすることにより、低い融点で接合行うことができ、しかも高い接合強度を得ることができる。



９　：ｎ型電極
１０：Ｎｉ層
１１：はんだ層
１２：接合材料
２１：ヒートシンク
２１ａ：金メッキ

【特許請求の範囲】

【請求項１】　電気素子の電極を基台に接合する接合材料であって、Ａｕを主体としたＡｕ－Ｓｎ－Ｎｉ合金であり、Ｎｉの組成比が１．3wt%以上１０wt%未満であることを特徴とする電気素子の接合材料。

【請求項２】　前記Ｎｉの組成比が２．５wt%以上であることを特徴とする請求項１に記載の電気素子の接合材料。

【請求項３】　前記Ｎｉの組成比が2wt%以上5wt%以下であることを特徴とする請求項１に記載の電気素子の接合材料。

【請求項４】　前記Ａｕ－Ｓｎ－Ｎｉ合金は、Ａｕを主体としたＡｕ－Ｓｎ合金とＮｉの積層構造を加熱して形成されたものであることを特徴とする請求項１乃至３のいずれか１つに記載の電気素子の接合材料。

【請求項５】　前記Ｎｉの膜厚が、５００Å以上であることを特徴とする請求項４に記載の電気素子の接合材料。

【請求項６】　前記Ａｕ－Ｓｎ合金は、物理的な気相成膜であることを特徴とする請求項４又は５に記載の電気素子の接合材料。

【請求項７】　前記Ａｕ－Ｓｎ合金の膜厚が、０．３～３μｍであることを特徴とする請求項５乃至６のいずれか１つに記載の電気素子の接合材料。

【請求項８】　前記基台は、前記電気素子が接合される面において、Ａｕ、Ｎｉ、Ｆｅ、Ｃｕのいずれかの材料を用いて構成されたものであることを特徴とする請求項１乃至７のいずれか１つに記載の電気素子の接合方法。

【請求項９】　前記電気素子が半導体レーザ素子であることを特徴とする請求項１乃至８のいずれか１つに記載の電気素子の接合方法。

【請求項１０】　電気素子の電極を基台に接合する方法において、

前記電極にＮｉ層を形成し、

このＮｉ層上にＳｎを含むはんだ層を直接形成し、

このはんだ層を加熱溶融して前記電気素子を前記基台に接合することを特徴とする電気素子の接合方法。

【請求項１１】　電気素子の電極を基台に接合する方法において、

前記電極にＮｉ層、およびＳｎを含むはんだ層をそれぞれ形成し、

前記はんだ層を加熱溶融して前記ＮｉとＳｎを相互拡散させ、前記電気素子を前記基台に接合することを特徴とする電気素子の接合方法。

【請求項１２】　前記Ｎｉ層を５００Å以上の膜厚にて形成することを特徴とする請求項１０又は１１に記載の電気素子の接合方法。

【請求項１３】　前記はんだ層を、合金を蒸着源とする物理的な気相成長により形成することを特徴とする請求項１０乃至１２のいずれか１つに記載の電気素子の接合方法。

【請求項１４】　前記はんだ層を、０．３～３μｍの膜厚で形成することを特徴とする請求項１０乃至１３のいずれか１つに記載の電気素子の接合方法。

【請求項１５】　前記はんだ層を、Ａｕを主体としたＡｕ－Ｓｎ－Ｎｉ合金で形成し、前記はんだ層の加熱溶融によりＮｉが１．3wt%から１０wt%含まれたＡｕ－Ｓｎ－Ｎｉ合金を形成することを特徴とする請求項１０乃至１４のいずれか１つに記載の電気素子の接合方法。

【請求項１６】　前記基台は、前記電気素子が接合される面において、Ａｕ、Ｎｉ、Ｆｅ、Ｃｕのいずれかの材料を用いて構成されたものであることを特徴とする請求項１０乃至１５のいずれか１つに記載の電気素子の接合方法。

【請求項１７】　前記電気素子が半導体レーザ素子であることを特徴とする請求項１０乃至１６のいずれか１つに記載の電気素子の接合方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、半導体レーザ素子等の電気素子を基台にはんだ付けする電気素子の接合材料および接合方法に関する。

【０００２】

【従来の技術】従来、半導体レーザ素子等の半導体素子を、金メッキされたヒートシンクやステム、回路基板等の基台にはんだ付けする場合、Ａｕ－Ｓｎ、Ｐｂ－Ｓｎ等の共晶はんだの成形ペレットが用いられていた。成形ペレットの場合、作製方法および取扱い上の理由から、数１００μｍ×数１００μｍで、膜厚として数１０μｍ以上が必要である。

【０００３】このため、はんだ層が必要以上の量となり、位置ずれが生じたり、半導体素子の周囲に隆起した縁部を形成したりする。半導体レーザ素子の場合、この隆起したはんだ層がレーザ光の障害になるといった問題が発生する。この問題を解決するものとして、特開昭５９－１７８７３６号公報に示すものがある。このものでは成形ペレットを使用せず半導体レーザ素子の金電極上に金の拡散を防止するバリヤー電極と金を含むはんだ材との薄膜を設け、薄膜はんだでの実装を行っている。また、特開平６－６９６０８号公報にも同様の技術が開示されている。

【０００４】

【発明が解決しようとする課題】しかしながら、はんだ層を薄膜にしても、はんだの量が少ないため、はんだ層と実装面との濡れ性が悪い場合、部分的にしか接続されず十分な接続強度と低接続抵抗が得られないという問題がある。本発明は上記問題に鑑みたもので、十分な接着強度と安定した電気的接続を得るように半導体素子を台座に接合することを目的とする。

【０００５】

【課題を解決するための手段】本発明者等は、ＳｎとＮｉが相性がよく、金属間化合物を形成することに着目した。ＧａＡｓ基板のドレイン電極として、従来よりＡｕとＧｅの合金にＮｉ、Ａｕを積層したもの（以下、この種の表記をＡｕ－Ｇｅ／Ｎｉ／Ａｕのように示す）が用いられている。このものではＮｉ膜厚を厚くすると接触抵抗が上がるとされＮｉ膜厚は２００Å程度で使用されている。この場合、ＮｉはＡｕの拡散を防ぐバリヤー電極として使用されている。従って、このものを用い、Ｓｎを含むはんだを蒸着し、それをヒートシンク等の台座にはんだ付けすることを試みた。

【０００６】しかしながら、Ｎｉ上のＡｕがはんだ層に拡散し、密着強度、濡れ性を低下させてしまうという問題が発生した。そこで、本発明者等は、Ａｕ層をなくしてはんだ付けしたところ、はんだの濡れ性が良く、接着強度の強いはんだ付けが安定して出来るようになった。これは、Ｎｉがはんだ層に拡散し、はんだ層中のＳｎがＮｉ中に拡散するという相互拡散が生じ、密着強度、濡れ性が向上したためである。

【０００７】また、半導体レーザ素子の接合に当たっては、接合温度を低くし半導体レーザ素子への熱損傷を軽減する接合材料を選定する必要があるが、この点に関しても種々検討したところ、後述するように、はんだ層としてＡｕ－Ｓｎはんだを用いた場合、ＮｉがＡｕ－Ｓｎ層に拡散し、Ａｕ－Ｓｎ－Ｎｉ合金を作り、接合温度を低くすることができた。

【０００８】本発明は上記検討をもとになされたものであり、その特徴は特許請求の範囲に記載した通りのものである。具体的には、以下の点を特徴とする。請求項１に記載の発明においては、電気素子（１～９）の電極（９）を基台（２１）に接合する接合材料（１２）であって、Ａｕを主体としたＡｕ－Ｓｎ－Ｎｉ合金であり、Ｎｉの組成比が１．３wt%以上１０wt%未満であることを特徴としている。

【０００９】請求項２に記載の発明では、請求項１に記載の電気素子の接合材料において、前記Ｎｉの組成比が２．５wt%以上であることを特徴としている。請求項３に記載の発明では、請求項１に記載の電気素子の接合材料において、前記Ｎｉの組成比が２wt%以上５wt%以下であることを特徴としている。請求項４に記載の発明では、請求項１乃至３のいずれか１つに記載の電気素子の接合材料において、前記Ａｕ－Ｓｎ－Ｎｉ合金は、Ａｕを主体としたＡｕ－Ｓｎ合金（１１）とＮｉ（１０）の積層構造を加熱して形成されたものであることを特徴としている。

【００１０】請求項５に記載の発明では、請求項４に記載の電気素子の接合材料において、前記Ｎｉの膜厚が、５００Å以上であることを特徴としている。請求項６に記載の発明では、請求項４又は５に記載の電気素子の接合材料において、前記Ａｕ－Ｓｎ合金は、物理的な気相成膜であることを特徴としている。請求項７に記載の発明では、請求項５乃至６のいずれか１つに記載の電気素子の接合材料において、前記Ａｕ－Ｓｎ合金の膜厚が、０．３～３μmであることを特徴としている。

【００１１】請求項８に記載の発明では、請求項１乃至７のいずれか１つに記載の電気素子の接合方法において、前記基台は、前記電気素子が接合される面において、Ａｕ、Ｎｉ、Ｆｅ、Ｃｕのいずれかの材料を用いて構成されたものであることを特徴としている。請求項９に記載の発明によれば、請求項１乃至８のいずれか１つに記載の電気素子の接合方法において、前記電気素子が半導体レーザ素子であることを特徴としている。

【００１２】請求項１０に記載の発明においては、電気素子（１～９）の電極（９）を基台（２１）に接合する方法において、前記電極にＮｉ層（１０）を形成し、このＮｉ層上にＳｎを含むはんだ層（１１）を直接形成し、このはんだ層を加熱溶融して前記電気素子を前記基台に接合することを特徴としている。

【００１３】請求項１１に記載の発明においては、電気素子（１～９）の電極（９）を基台（２１）に接合する方法において、前記電極にＮｉ層（１０）、およびＳｎを含むはんだ層（１１）をそれぞれ形成し、前記はんだ層を加熱溶融して前記ＮｉとＳｎを相互拡散させ、前記電気素子を前記基台に接合することを特徴としている。

【００１４】請求項１２に記載の発明では、請求項１０又は１１に記載の電気素子の接合方法において、前記Ｎｉ層を５００Å以上の膜厚にて形成することを特徴としている。請求項１３に記載の発明では、請求項１０乃至１２のいずれか１つに記載の電気素子の接合方法において、前記はんだ層を、合金を蒸着源とする物理的な気相成長により形成することを特徴としている。

【００１５】請求項１４に記載の発明では、請求項１０乃至１３のいずれか１つに記載の電気素子の接合方法において、前記はんだ層を、０．３～３μmの膜厚で形成することを特徴としている。請求項１５に記載の発明では、請求項１０乃至１４のいずれか１つに記載の電気素子の接合方法において、前記はんだ層を、Ａｕを主体としたＡｕ－Ｓｎ－Ｎｉ合金で形成し、前記はんだ層の加熱溶融によりＮｉが１．３wt%から１０wt%含まれたＡｕ－Ｓｎ－Ｎｉ合金を形成することを特徴としている。

【００１６】請求項１６に記載の発明では、請求項１０乃至１５のいずれか１つに記載の電気素子の接合方法において、前記基台は、前記電気素子が接合される面において、Ａｕ、Ｎｉ、Ｆｅ、Ｃｕのいずれかの材料を用いて構成されたものであることを特徴としている。請求項１７に記載の発明では、請求項１０乃至１６のいずれか１つに記載の電気素子の接合方法において、前記電気素子が半導体レーザ素子であることを特徴としている。

【００１７】なお、上記カッコ内の符号は、後述する実施例記載の具体的構成との対応関係を示すものである。

【0018】

【発明の作用効果】請求項１乃至９に記載の発明によれば、接合材料を、Ａｕを主体としたＡｕ－Ｓｎ－Ｎｉ合金で、Ｎｉの組成比を１．３wt%以上１０wt%未満としているから、低い融点で強度の高い接合を行うことができ、しかも接触抵抗の増加を抑制することができる。

【0019】特に、請求項２に記載の発明によれば、Ｎｉの組成比を２．５wt%以上としているから、安定した高い接合強度を得ることができる。また、請求項３に記載の発明によれば、Ｎｉの組成比を2wt%以上5wt%以下としているから、融点を一層低くすることができる。また、請求項５に記載の発明によれば、Ｎｉの膜厚を５００Å以上としているから、接着強度を高くすることができる。

【0020】また、請求項６に記載の発明によれば、はんだ層を物理的な気相成膜としているから、膜厚のばらつきに対する融点の変化はほとんどなく、安定した強度を得ることができるとともに、安定した電気的接続を得ることができ、さらに必要以上のはんだのはみ出しをなくすことができる。また、請求項７に記載の発明によれば、Ａｕ－Ｓｎ合金の膜厚を０．３～３μmとしているから、接着強度を高めることができる。。

【0021】請求項１０乃至１７に記載の接合方法の発明においては、電気素子の電極にＮｉ層、Ｓｎを含むはんだ層を形成し、さらにこのはんだ層を溶融して基台に接合するようにしている。ここで、はんだ層の溶融時に、Ｎｉ層中のＮｉがはんだ層に拡散し、はんだ層中のＳｎがＮｉ層中に拡散するという相互拡散が生じる。この相互拡散により、密着強度、濡れ性を向上させることができる。

【0022】

【実施例】以下、本発明を半導体レーザに適用した実施例について説明する。半導体レーザ素子は、ＧａＡｓやＩｎＰ基板の上にエピタキシャル成長を行い結晶中に各動作領域を設けたものである。一般的に基板にはｎ型の基板を使用する。材料系としてはＧａＡｓ－ＡｌＧａＡｓ系、ＩｎＧａＡｓＰ－ＩｎＰ系、ＩｎＧａＰ－ＩｎＧａＡｌＰ系等を用いることができる。エピタキシャル成長方法としては、液層エピタキシャル、分子線エピタキシ（ＭＢＥ：molecular beamepitaxy ）、有機金属気相エピタキシ（ＭＯＣＶＤ：metal organic chemicalvapaor deposition ）等を用いることができる。活性層としてはダブルヘテロ構造、量子井戸構造等とすることができる。

【0023】図1に、半導体レーザ素子の斜視図を示す。ｎ－ＧａＡｓ基板１上に、ｎ－ＧａＡｓバッファ層２、ｎ－ＡｌＧａＡｓクラッド層３、ＡｌＧａＡｓ／ＧａＡｓ多重量子井戸構造からなる活性層４、ｐ－ＡｌＧａＡｓクラッド層５、ｐ－ＧａＡｓ層６が順に積層されており、活性層４～ｐ－ＧａＡｓ層６はメサ状に形成されている。また、ｎ－ＡｌＧａＡｓクラッド層３及びメサ部の上面に、絶縁膜７が窓部を有して形成され、この絶縁膜7上にｐ型電極（上部電極）８が形成されている。

【0024】このｐ型電極8は、電子ビーム蒸着、スパッタ法などにより所定の厚さに成膜して形成される。ｐ型電極8としては、Ａｕ－Ｚｎ／Ａｕ、Ｃｒ／Ａｕ、Ｍｏ／Ａｕ、Ｔｉ／Ｐｔ／Ａｕなどを用いることができるが、オーミックコンタクトをとることができるものであれば他の材料でもよい。ｎ－ＧａＡｓ基板１の裏面には、Ａｕ－Ｇｅからなるｎ型電極（下部電極）９が形成されており、ｎ型電極９の表面には、Ｎｉ層１０およびはんだ層１１からなる接合材料が形成されている。

【0025】上記のように構成された半導体レーザ素子は、ヒートシンク、他の半導体基板や回路基板などに接合される。この実装方法について説明する。図１に示す半導体レーザ素子を、図２に示すヒートシンク２１の上に複数個乗せ、積層型とする。これを符号２２で示す。この場合、下側の半導体レーザ素子のｐ型電極上に上側の半導体レーザ素子の接合材料が位置される。

【0026】ヒートシンク２１はＣｕ、Ｆｅ等からなっており、表面はＮｉ、Ａｕ等の導伝率の高い金属がメッキ又は蒸着、スパッタ法などにより形成されている。複数個の半導体レーザ素子をそれぞれ位置合わせしてヒートシンク２１上に積み上げる。このとき、チップの搬送は真空ピンセットを用い、これがヒータ加熱時に加圧部として兼ねるものが位置精度を出し易いので望ましい。

【0027】ヒートシンク２１上に積み上げられた半導体レーザ素子がずれないようにして加圧し、それぞれの半導体レーザ素子のはんだ層１１を溶かし、接着させるように加熱を行う。はんだが溶ける温度になってから数秒から数分その状態で放置し、その後冷却を行う。加熱方法はヒートシンク、半導体レーザチップ全体を位置ずれが生じないように固定し、全体を恒温層などで加熱する方法、あるいはヒートシンクの裏面からヒータなどで加熱する方法等があるが、装置作業方法の容易性から後者の方が望ましい。

【0028】上記したダイボンドの次には半導体レーザと電気的コンタクトをとるために上部電極と駆動回路配線とをＡｕ、Ｐｔ等のワイヤー２３でボンディングする。その後、必要に応じてカン封入を行い半導体レーザの完成品とする。上記したｎ型電極９、Ｎｉ層１０、はんだ層１１の形成およびヒートシンク２１への接合について説明する。この部分の構成を図３に示す。

【0029】ｎ－ＧａＡｓ基板１の裏面に形成されるｎ型電極9は、オーミック電極を形成するため、Ａｕ－Ｚｎ／Ａｕ、Ｃｒ／Ａｕ、Ｔｉ／Ｐｔ／Ａｕ、Ａｕ－Ｇｅ／Ｎｉ／Ａｕ、Ａｕ－Ｓｎ／Ａｕ等やこれらの合金積層膜が電極材料として用いられる。これを真空蒸着法である電子ビーム蒸着、抵抗加熱蒸着、スパッタ法等により

所定の厚さにてｎ－ＧａＡｓ基板１の裏面に形成する。

【００３０】次に、Ｎｉ層１０を同様の方法でｎ型電極９上に形成する。続いて、はんだ層１１としてＡｕ－Ｓｎ、Ｐｂ－Ｓｎ等のＳｎを含む合金をＮｉ層１０の上に形成する。はんだ層の形成方法については後述する。このようにして作製した電極９／Ｎｉ層１０／Ｓｎを含むはんだ層１１を、Ｎｉ、Ａｕ等の金属メッキ２１ａを施したヒートシンク２１に乗せ、加圧、加熱を行い、はんだ層１１を溶融して冷却することにより半導体レーザ素子をヒートシンク２１上に実装する。

【００３１】はんだ材料にはＡｕ－Ｓｎ、Ａｕ－Ｓｉ、Ｉｎ、Ｉｎ－Ｐｂ、Ｐｂ－Ｓｎ、Ａｕ－Ｐｂ、Ａｕ－Ｇｅ等があるがＡｕ－Ｓｎ、Ｐｂ－Ｓｎ等のＳｎを含むはんだとＮｉを積層してはんだ付けを行うことにより濡れ性が良く接着強度の強い接合が得られる。特に、はんだ材にＡｕ－Ｓｎを用いた場合に効果がある。Ｎｉ層１０の役目は、はんだ材と電極が相互拡散を起こさないようにするバリヤー電極の役割と、はんだ層に拡散してはんだの濡れ性を向上する役目を持つ。ＧａＡｓ半導体では電極の最上層にＡｕを用いることが多くＡｕは活性であり接続しようするはんだ層に低温で拡散し、コンタクトの安定性が悪くなる。このためにバリヤー電極は必要であり、特に電極がＡｕおよびＡｕの合金の場合有効である。

【００３２】バリヤー電極としてのＮｉの膜厚は少なくとも２００Å必要である。これ以下では島状の膜となり、バリヤー金属の役目を果たさない。図４に、０．５ｍｍ×０．５ｍｍのｎ－ＧａＡｓ基板にＡｕ－Ｇｅ電極を１０００Å成膜し、その上にＮｉ／Ａｕ－Ｓｎ（ＡｕとＳｎは共晶組成のもの）を積層して実装し、振動試験した場合の接着層の強度のＮｉ膜厚依存性を示す。この振動試験は、ＪＩＳ　Ｃ７０２２Ａ－１０、条件Ｄ、振動数範囲１０～２０００Ｈｚ、加速度２０Ｇ、方向３方向、時間４８分の条件で行った。なお、Ａｕ－Ｓｎはんだ層１１の厚さは１．５μｍ一定とした。

【００３３】Ｎｉ層１０の膜厚が厚くなるに従って接着強度が大きくなっており、膜厚１０００Å以上では強度に差がない。膜厚１０００Å以上では試験中に基板が割れてしまうため強度はこれ以上であると思われる。また、膜厚が２００Åでは剥がれが生じ、十分な接着強度が得られていない。接着強度が５００ｇｆ以上あれば十分に強度があり各種信頼性試験に耐えることができたため、Ｎｉ膜厚を５００Å以上とする必要がある。

【００３４】次に、はんだ層１１を形成する方法について説明する。はんだ層１１の形成に際し、Ａｕ－Ｓｎ等の合金の構成材料を積層して作成することを試みた。この場合、組成比の設計は自由に出来、蒸着材料の管理も容易である。しかしながら、これでは各層の膜厚がばらついた場合すぐに組成ずれとなる。通常、はんだの組成比は共晶組成を用いるのが一般的であり、組成ずれを起こした場合、融点は高くなる。このように融点が変化すると、実装の条件をそのたびに変えなくてはならない。もし、同じ条件で行えばはんだ材料が溶けなかったり、溶けても充分に溶けずに実装後、安定した密着強度が得られなくなる。

【００３５】そこで、はんだ層１１としてＡｕ－Ｓｎ、Ｐｂ－Ｓｎ、Ｉｎ、Ｉｎ－Ｐｂ、Ａｕ－Ｓｉ、Ａｕ－Ｐｂ等の合金を気相成長により成膜することを検討した。すなわち、上記合金を蒸着源とした物理的な気相成長によりはんだ層１１を成膜するというものである。ここで、物理的な気相成長とは、Physical Vapor Deposition（ＰＶＤ）といい、化学的な反応を利用せず、物理的な変化を利用して薄膜を形成する方法であり、蒸着、スパッタ、イオンプレーティング等がある。物理的な気相成長を言い換えれば、基板上に成膜される材料自体が蒸気やクラスターの状態で基板に到達し薄膜となることをいう。一方、化学反応を利用した方法として、Chemical Vapor Deposition（ＣＶＤ）法があり、これは原料を気相中において、熱、プラズマ、光などのエネルギーを用い、分解反応させ化学反応を用いて薄膜となり、ＰＶＤとは成膜の原理が異なる。

【００３６】このようにして、はんだ層１１を形成することにより、例え膜厚がばらついても常に融点の変化はほとんどなく、上記のような問題を解消することができた。気相成長による成膜方法としては、電子ビーム蒸着、抵抗加熱蒸着、スパッタ法などを用いることができる。これらのうち電子ビーム蒸着、抵抗加熱蒸着では合金の蒸気圧の差により原料と組成比が幾らかずれるので、成膜方法としてはスパッタ法を用いるのが望ましい。なお、電子ビーム蒸着、抵抗加熱蒸着を用いた場合、原料をほとんど全て飛ばしきれば原料と組成比の変化はなく、また全ての原料を蒸着しなくても蒸気圧により組成比が決まるため膜の組成比がバッチ毎に異なることはない。

【００３７】はんだ層として成形ペレットを使用した従来のものにおいては、過剰なはんだによる隆起物が時として発光層まで隠すことがあり光出力の妨げとなるという問題があったが、上記のように、はんだ層１１を気層成長による薄膜とすることにより、必要以上のはんだのはみ出しがなくなり、再現性の良い組成比のはんだ層が得られ安定した密着強度の強い接合が可能となった。

【００３８】次に、上記はんだ層１１の膜厚について説明する。はんだ層を気層成長による薄膜とすることで必要以上のはんだのはみ出しはなくなったが、上記のように半導体レーザ素子を複数個積層する場合には、はんだ層の厚さが厚いと、はんだのはみ出しにより発光層を覆ってしまうという問題がある。また、発光層に近い側の電極をはんだ付けする場合（後述する作成例２のような場合）も同様の問題が発生する。逆に、はんだ層が薄い場合には密着強度が弱いという問題がある。

【0039】図5に、0．5mm×0．5mmの半導体レーザ素子を、金メッキした銅ヒートシンクに実装したときのはんだ層の厚さと密着強度の関係を示す。密着強度ははんだ層の膜厚が厚くなるほど強くなっており1μm以上では強度の差がない。膜厚が1μm以上では基板が割れてしまうために強度はこれ以上あると考えられる。接着強度は500gf以上あれば充分に強度があり各種信頼性試験に耐えられることがわかっている。従って、はんだ層の膜厚は3000Å以上あればよい。

【0040】はんだ層の厚さは接着面の表面荒さと関係があり、今回この測定にはRa＝1000Åを用いた。一般に、はんだ層の膜厚は表面荒さよりも厚い必要があり、今回の結果より表面荒さの3倍程度の厚さが必要であることがわかった。実装に用いられるステムの接着面の表面荒さRa＝500～2500Åのものが用いられる。ステムの表面荒さは通常1000Åのものが使われているので、はんだ層の厚さは少なくとも3000Å以上必要であり、望ましくは5000Å以上がよい。

【0041】はんだ層の膜厚は厚くなるほど密着強度が強いが、厚くなるとはんだ層のはみだしが問題となる。特に、複数個実装した場合はんだ層のはみ出しが発光層を覆うこととなる。さらに、膜厚が厚くなると成膜時間も長くなり、かつ蒸着材料の量も多くなる等の問題が生じる。はんだ層のはみ出しは、はんだ層が1μmの厚さまではほとんど無いが、それ以上の厚さになるとチップの裏面以外にはみ出してくる。はんだ層の厚さを3μmより大きくすると発光面側にはんだが付き、4μm以上では発光層を覆うところが発生した。従って、はんだ層の膜厚は3μm以下がよい。

【0042】従って、はんだ層11の膜厚を0．3～3μmにすることにより密着強度の強い接合が可能となる。また、半導体レーザを複数個積層する場合は積層部のはんだが発光層を覆うこともなく密着強度が強く安定した光出力が得られる。上記したはんだ層11を用いた半導体素子の作成例を示す。

（作成例1）n－GaAs基板上にGaAs／AlGaAs系半導体レーザ素子を作製し、そのn型電極側を、金メッキを行った銅ヒートシンク上にはんだ付けを行った。この時、半導体レーザ素子を3個積層した。n型電極としてAu88wt%－Gewt12%を1000Å形成し、その上にNiを1000Å、Au－Snはんだを1μm設けた。この時、Au－Ge／Niは、E．B．蒸着を用いて成膜し、はんだ層はスパッタ法により成膜した。半導体レーザ素子のサイズは500×600×110μmとした。この素子を金メッキを行った銅ヒートシンク上に3個重ねて置き、加熱温度340℃、加圧加重60gで実装を行った。実装した素子ははんだ層のはみ出しもなく、はんだが発光層を覆うこともなかった。この素子を可変周波数10～2000Hz、20G／sec²、48分、3方向を行ったところ、試験前となんら変化がなかった。この素子の接着強度をシェアーテスターで測定したところ1kgf以上の強度を得た。

（作成例2）n－GaAs基板上にInGaP－InGaAlP系半導体レーザ素子を作製し、そのp型電極側を、金メッキを行った銅ヒートシンク上にはんだ付けを行った。p型電極としてTi1000Å、Pt2000Å、Au3000Åをそれぞれ形成し、その上にNiを800Å、Au－Snはんだを0．8μm設けた。この時、成膜にはE．B．蒸着を用いた。半導体レーザ素子のサイズは600×700×110μmとした。p型電極をはんだ付けしたが、はんだ層が活性層を覆うこともなく良好な光出力を得た。さらに、密着強度も1kgf以上の値を得、安定したコンタクトを得た。

（作成例3）半絶縁GaAs基板上にGaAs電界効果トランジスタ素子を作製し、金メッキを行ったプリント基板にはんだ付けを行った。基板裏面にAu－Snはんだを2μm設けた。この時スパッタ法により成膜した。素子サイズは500×600×180μmである。この素子を加熱温度360℃、加圧加重100gで実装した。この素子の接着強度をシェアーテスターで測定したところ1kgf以上の強度を得た。

【0043】次に、はんだを用いた接合材料について説明する。上述したような半導体レーザ素子をヒートシンクに接合する場合、濡れ性もしくは接合強度を向上させるためには、接合温度、接合時の加圧圧力、加圧時間等の設定値を大きくすることが有効であるが、半導体レーザ素子の材料として用いられるGaAs中のAsは昇華温度が低いため、高い接合温度は素子に与える熱損傷を増大する。また、高い加圧圧力および長い加圧時間も発光層に与える機械的損傷を増大する。

【0044】従って、半導体レーザ素子の接合に当たっては、接合温度を低くし半導体レーザ素子への熱損傷を軽減する接合材料を選定する必要がある。本発明者等は、上記の点に関し種々検討した結果、はんだ層11としてAu－Sn系はんだを用い、Ni／（Au80wt%－Sn20wt%）の積層構造とした時に、Au80wt%－Sn20wt%ペレットよりも低い融点が得られることを見い出した。これは、NiがAu－Sn層に拡散し、Au－Sn－Ni合金を作ることによるものである。

【0045】これを踏まえて、Ni膜厚を変化させ、Au80wt%－Sn20wt%中に熱拡散するNi濃度を変化させて状態図を作成した。その結果を図6に示す。この図において、L、Sはそれぞれ液相、固相を示し、α、βはそれぞれAu－Sn－Niの固溶体を示す。従って、（L＋α）、（L＋β）はそれぞれ液相、固相の混合状態であることを表す。上側の横軸にはNi／（Au80wt%－Sn20wt%）層構造においてAu80wt%－Sn20wt%の膜厚を1．5μmとしたときのNiの膜厚を示す。

【0046】この状態図より、（Au80wt%－Sn2

0wt％）－Ｎｉ合金はＮｉの量が増えることによりＡｕ８０wt％－Ｓｎ２０wt％ペレットの融点より低くなり、Ｎｉの組成比（接合材料の全重量に対するＮｉの重量比）を１．３wt％とした時に融点が１０℃程度低くなる。さらに、Ｎｉの量を増やし、3wt％程度とした時に最も融点が低くなり、Ａｕ８０wt％－Ｓｎ２０wt％ペレットに比べ２５℃以上低下する。従って、従来Ａｕ８０wt％－Ｓｎ２０wt％ペレットの融点で接合していたのに対し接合温度を２５℃以上低下させることができ、素子への熱損傷を低減することができる。

【００４７】なお、上記した効果および後述する効果は、ＮｉがＡｕ－Ｓｎ層に拡散し、Ａｕ－Ｓｎ－Ｎｉ合金を作ることによるものであり、従ってＮｉ／（Ａｕ８０wt％－Ｓｎ２０wt％）の積層構造としたものに限らず、（Ａｕ８０wt％－Ｓｎ２０wt％）－Ｎｉ合金層としたものでも同様に得ることができる。図7に、Ａｕ８０wt％－Ｓｎ２０wt％中のＮｉの組成比と接合強度の関係を示す。この図から、接合強度はＮｉの組成比が多くなるに従って強くなるが２．５wt％以上の組成では飽和することがわかる。実験では、９．５wt％まで強度の測定を行って充分な強度があることが確認されている。

【００４８】接合強度試験において、Ｎｉ組成比が０．７wt％の従来構造ではヒートシンクとはんだの接着面で剥離するが、Ｎｉ組成比１．３wt％以上では接合面では剥離せず、接合されている素子部が破壊される。接合強度は５００ｇｆ以上であれば充分各種の信頼性試験に耐えられることがわかっているので、Ｎｉ組成比は１．３wt％以上であれば安定した接合強度が得られる。

【００４９】なお、図7において、Ｎｉ組成比１．３wt％、１．７wt％の場合は、５０ｇの加圧加重を加えたものであり、２．５wt％以上の場合は、加圧を行わず素子の自重だけで接合を行ったものである。従って、Ｎｉ組成比を２．５wt％以上とすることにより素子の自重だけでも充分な接合強度を得ることができる。これらの結果から、Ａｕ８０wt％－Ｓｎ２０wt％中にＮｉを添加することにより、はんだの融点が下がり、さらには接合強度が強くなることがわかる。Ｎｉの組成比は融点が１０℃以上低下する1wt％から１０wt％がよく、濡れ性と接合強度を考慮すれば１．３wt％以上が望ましい。最も低い融点が得られ、はんだ凝固後の組成が長期的に均一に保たれることから、Ｎｉの組成比は3元系での3wt％前後の2wt％から5wt％が特に望ましい。

【００５０】なお、Ｎｉ組成比をＡｕ－Ｇｅ上のＮｉ膜厚を厚くすることにより増加させた場合、Ｎｉの組成比が１０％以上になると、Ｓｎ－Ｎｉの金属間化合物が生成され、その金属間化合物は絶縁体であるので接合部の抵抗値が高くなる。従って、接合部の抵抗値増加を考慮すればＮｉの組成比を１０％未満とするのが好ましい。

【００５１】このように半導体レーザ素子を台座等に接合する際、接合材料がＡｕ－Ｓｎ共晶はんだ中に一定量のＮｉを含むはんだ材料であり、台座表面がＡｕ層であることにより、濡れ性が良く接着強度の強い接合が安定してできるようになった。なお、上記Ｎｉ／（Ａｕ８０wt％－Ｓｎ２０wt％）の積層構造のものにおいても、上述したようにＮｉの膜厚を５００Å以上とし、Ａｕ－Ｓｎ合金はんだ層の膜厚を０．３～３μｍにするのが好ましい。

【００５２】上記接合材料を用いた作成例について説明する。

（作成例４）ｎ－ＧａＡｓ基板上にＧａＡｓ／ＡｌＧａＡｓ系半導体レーザ素子を作製し、そのn型電極側を、金メッキを行った銅ヒートシンク上にはんだ付けを行った。n型電極としてＡｕ８８wt％－Ｇｅ１２％を０．１μｍを形成し、その上にＮｉを０．１μｍ、Ａｕ－Ｓｎはんだを１．５μm設けた。この時、（Ａｕ－Ｇｅ）／Ｎｉは、Ｅ．Ｂ．蒸着を用いて成膜し、はんだ層はスパッタ法により成膜した。半導体レーザ素子のサイズは５００×６００×１１０μｍとした。この素子を金メッキを行った銅ヒートシンク上に置き、加熱温度３４０℃、加圧加重を加えずに実装を行った。この素子を可変周波数１０～２０００Ｈｚ、２０Ｇ、４８分、３方向の振動試験を行ったところ、試験前となんら変化がなかった。この素子の接合強度をテスタで測定したところ１ｋｇ程度の強度を得た。このときの接合材料の組成比はＡｕ７７．３wt％－Ｓｎ１９．３wt％－Ｎｉ３．４wt％であった。

（作成例５）ｎ－ＧａＡｓ基板上にＩｎＧａＰ－ＩｎＧａＡｌＰ系半導体レーザ素子を作製し、そのｐ型電極側を、金メッキを行った銅ヒートシンク上にはんだ付けを行った。ｐ型電極としてＴｉを０．１μｍ、Ｐｔを０．２μｍ、Ａｕを０．３μm形成し、その上にＮｉを０．１μｍ、Ａｕ－Ｓｎはんだを１．０μm設けた。この時、成膜にはＥ．Ｂ．蒸着を用いた。半導体レーザ素子のサイズは６００×７００×１１０μｍとした。加熱温度３４０℃、加圧加重３０ｇでｐ型電極をはんだ付けしたが、はんだ層が活性層を覆うこともなく良好な光出力を得た。さらに、接合強度も１ｋｇｆ以上の値を得、安定したコンタクトを得た。このときの接合材料の組成比はＡｕ７６wt％－Ｓｎ１９wt％－Ｎｉ５wt％であった。

（作成例６）半導体レーザ素子のｐ型電極側の上面に、上側半導体レーザ素子のｎ型電極側をはんだ付けし、積層構造とした。ｐ型電極としてＣｒを０．０４μｍ、Ｐｔ層を０．１μｍ、Ａｕ層を０．５μｍを形成した。ｎ型電極としてＡｕ８８wt％－Ｇｅwt１２％を０．１μｍ形成し、その上にＮｉを０．１μｍ、Ａｕ－Ｓｎはんだを１．５μｍ設けた。この時、（Ａｕ－Ｇｅ）／Ｎｉは、Ｅ．Ｂ．蒸着を用いて成膜し、はんだ層はスパッタ法により成膜した。半導体レーザ素子のサイズは６００×７００×１１０μｍとした。加熱温度３４０℃、加圧加重３０ｇでｐ型電極上にｎ型電極をはんだ付けした。

接着強度をシェアーテスターで測定したところ５００ｋｇｆ以上の強度を得た。この時、はんだ層が活性層を覆うことなく良好な光出力を得た。また、半導体レーザ素子を積層構造とすることにより、出力を増大させることができた。このときの接合材料の組成比はＡｕ７７．３wt%－Ｓｎ１９．３wt%－Ｎｉ３．４wt%であった。

【００５３】上記した種々の実施例においては、台座としてＡｕ、Ｎｉ等のメッキを施したヒートシンクを示したが、Ｆｅ、Ｃｕ等の台座を対象にして、半導体素子をはんだ付けするようにしてもよい。また、半導体素子として半導体レーザ素子を対象にしたものについて説明したが、その他の半導体素子にも本発明を適用することができる。この場合、オーミック電極以外にショートキー電極を用いるものにも適用することができる。このショートキー電極の材料としては、Ａｌ、Ｐｔ、Ａｕ、Ｔａ、Ｃｒ、Ｗ、Ｍｏ、Ｔｉ、Ｃｕ、Ａｇ、Ａｉ－Ｓｉとすることができる。

【００５４】また、半導体素子以外に、チップ抵抗、チップコンデンサ等の電気素子にも本発明を適用することができる。次に、上記したＡｕ－Ｓｎ－Ｎｉ接合材料の他の適用例について説明する。

（作成例７）液晶表示装置やエレクトロルミネッセンス（以下、ＥＬという）表示装置の駆動ＩＣ３０をガラス基板３１上に実装し、導体（電極）３２と接続する場合、図8に示す（ａ）（ｂ）（ｃ）に示す構成のものがある。（ａ）はマウントパッド３３およびワイヤ３４を用いたもの、（ｂ）はバンプ３６を用いたもの、（ｃ）はビームリード３７を用いたものである。上記Ａｕ－Ｓｎ－Ｎｉ接合材料は、（ａ）ではマウント部３５とマウントパッド３３の接合材料に、（ｂ）ではバンプ３６として、（ｃ）ではビームリード３７として用いられる。

【００５５】以下、（ａ）の構成を用いてＥＬパネルに駆動ＩＣ３０を実装する例について説明する。ＥＬパネルを作製するため、まずガラス基板３１上に透明電極としてＩＴＯを０．１μmを形成し、ストライプ上に加工した。次に、発光層としてＣａＳ：ＥｕをＥ．Ｂ．蒸着法により１μm形成した。次に、絶縁層として、SiO_2をＲＦ、Ｐ－ＣＶＤにより０．３μm形成し、ついで背面電極３２としてＡｌを０．１５μm成膜し所定のパターンにパターニングを行った。次に、マウントパッド３３と配線の取り出しパッドとして、まずＮｉを０．１μm成膜し、ついでＡｕを０．５μm成膜し、パターニングを行った。成膜はスパッタ法で行った。最後に、ガラス基板３１をエポキシ樹脂により接合し、シリコンオイルを封入して保護層を形成しＥＬパネルとした。

【００５６】ついで、駆動ＩＣ３０をガラス基板３１に接合するため、駆動ＩＣ３０の裏面に、Ｎｉを０．２μm成膜し、ついで（Ａｕ８０wt%－Ｓｎ２０wt%）を２μm成膜した。いずれも成膜はスパッタ法で行った。これをマウントパッド３５に３５０℃、加圧加重８０ｇにて接合した。一方、Ａｕワイヤ３４を用いＥＬパネル配線の取り出しパッドと駆動ＩＣ３０の取り出しパッドを配線した。このようにしてガラス基板３１上に安定した接合強度で駆動ＩＣ３０の実装を行った。このときの接合材料の組成比はＡｕ７６wt%－Ｓｎ１９wt%－Ｎｉ５wt%であった。

（作成例８）図9に、SiN_x光導波路を設けたＳｉ基板４２とＧａＡｓ／ＡｌＧａＡｓ系半導体レーザ素子４０とをバンプ４４を用いて接合した例を示す。バンプ４４として（Ａｕ７８wt%－Ｓｎ１９．５wt%）－Ｎｉ２．５wt%の接合材料を使用し、バンプ径４０μmのものを４つ使用して、半導体レーザ素子４０をＳｉ基板４２に実装した。バンプ４４はＳｉ基板４２上のＡｕパッド４３上に形成した。半導体レーザ素子４０の裏面電極４１には（Ａｕ－Ｇｅ）／Ｎｉ／Ａｕを用い、膜厚はそれぞれ０．１μm、０．０２μm、０．４μmとした。半導体レーザ素子４０をバンプ４４に乗せ、基板全体を３６０℃の恒温層にてリフローを行い、接合を行った。このようにしてＳｉ基板４２上に半導体レーザ素子４０を実装した。

【図面の簡単な説明】

【図１】本発明を半導体レーザ素子に適用した場合の実施例を示す半導体レーザ素子の斜視図である。

【図２】半導体レーザ素子をヒートシンクにダイボンドした状態を示す斜視図である。

【図３】ｎ－ＧａＡｓ基板の裏面に形成されるｎ型電極、Ｎｉ層およびはんだ層をヒートシンク等の台座へ接合する時の構成を示す模式図である。

【図４】振動試験した場合のＮｉ膜厚と接着強度の関係を示す特性図である。

【図５】はんだ層厚さと密着強度との関係を示すグラフである。

【図６】Ａｕ８０wt%－Ｓｎ２０wt%中に熱拡散するＮｉ濃度を変化させた時の融点の変化を示す図である。

【図７】Ａｕ８０wt%－Ｓｎ２０wt%中のＮｉの組成比と接合強度の関係を示す図である。

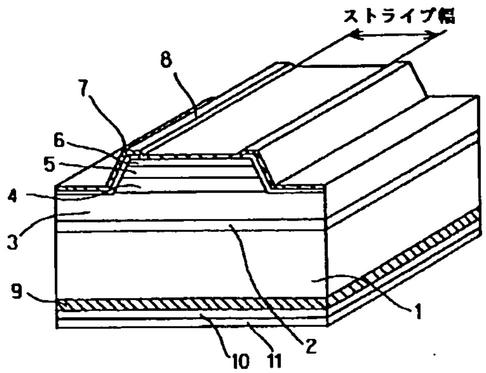
【図８】表示装置の駆動ＩＣをガラス基板上に実装する構成を示す図である。

【図９】SiN_x光導波路を設けたＳｉ基板に半導体レーザ素子を実装した構成を示す図である。

【符号の説明】

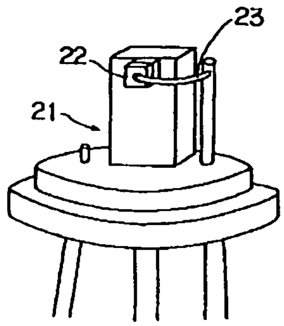
１…ｎ－ＧａＡｓ基板、２…バッファ層、３、５…クラッド層、４…活性層、６…ｐ－ＧａＡｓ層、７…絶縁膜、８…ｐ型電極、９…ｎ型電極、１０…Ｎｉ層、１１…はんだ層、２１…ヒートシンク．

【図1】

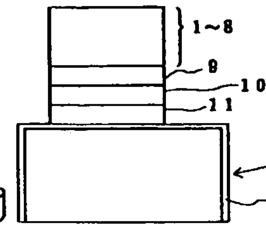


1　n－GaAs基板
2　n－GaAsバッファ層
3　n－AlGaAsクラッド層
4　活性層
5　P－AlGaAsクラッド層
6　P－GaAs層
7　絶縁膜
8　P型電極
9　n型電極
10　Ni層
11　はんだ層

【図2】

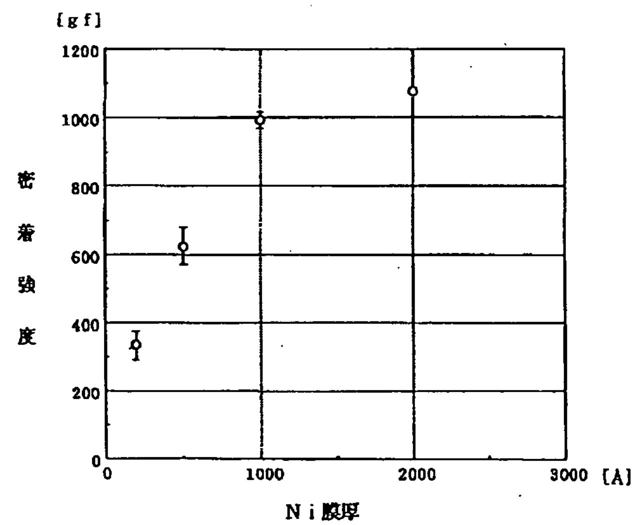


【図3】

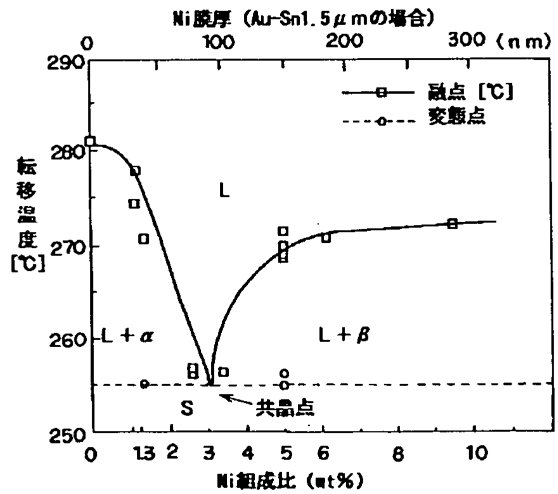


9：n型電極
10：Ni層
11：はんだ層
12：接合材料
21：ヒートシンク
21a：金メッキ

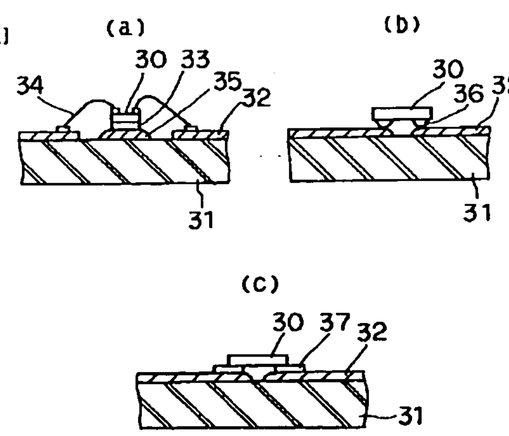
【図4】



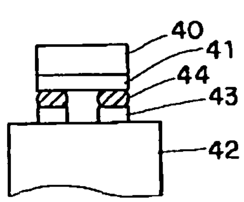
【図6】



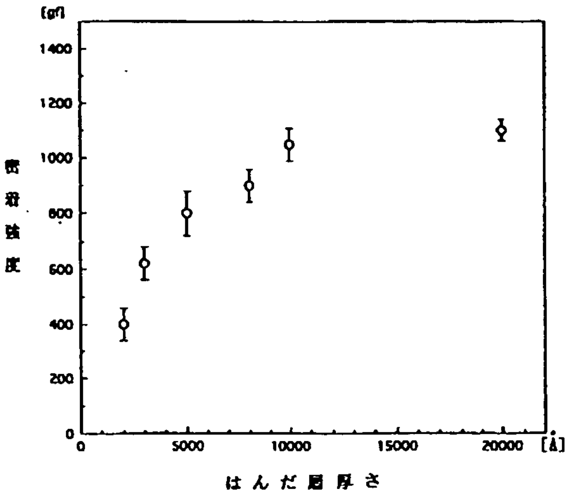
【図8】



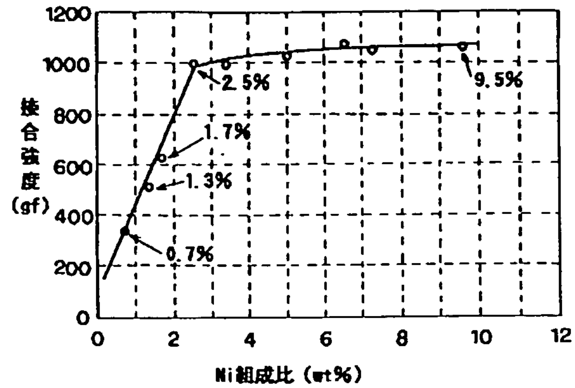
【図9】



【図5】



【図7】



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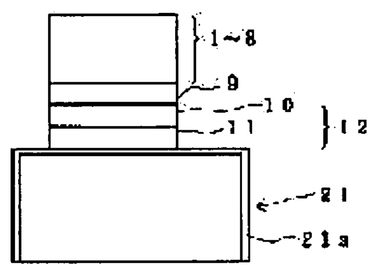
(54) BONDING MATERIAL AND BONDING METHOD OF ELECTRIC ELEMENT

(57)Abstract:
PURPOSE: To join a semiconductor element to a pedestral with a sufficient adhesion and a stable electric connection.
CONSTITUTION: An Ni layer 10 and an Au-Sn solder layer 11 are formed on an N-type electrode 9 as the ohmic electrode of a semiconductor laser element. The solder layer 11 is fused and bonded to a heat sink 21 plated with gold 21a. The thickness of the Ni layer 10 is 500Å or greater. At the time of fusion of the solder layer 11, Ni in the Ni layer 10 diffuses in the solder layer 11, and Sn in the solder layer 11 diffuses in the Ni layer 10. As the result of mutual diffusion, the adhesion and the wettability can be improved. The composition ratio of the Ni layer 10 is set higher than or equal to 1.3wt.% and lower than 10wt.% to the Au-Sn solder layer 11. Thereby bonding is enabled at a low melting point and high bonding strength can be obtained.



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CLAIMS

[Claim(s)]
[Claim 1] The cementing material of the electric element characterized by being the cementing material which joins the electrode of electric element to a pedestal, being the Au-Sn-nickel alloy which made Au the subject, and the composition ratio of nickel being less than [more than 1.3wt%10wt%].
[Claim 2] The cementing material of the electric element according to claim 1 characterized by the composition ratio of Above nickel being more than 2.5wt%.
[Claim 3] The cementing material of the electric element according to claim 1 characterized by the composition ratio of Above nickel being less than [more than 2wt%5wt%].
[Claim 4] The aforementioned Au-Sn-nickel alloy is the cementing material of the claim 1 characterized by heating the laminated structure of the Au-Sn alloy which made Au the subject, and nickel, and being formed, or the electric element of any one publication of three.
[Claim 5] The cementing material of the electric element according to claim 4 to which thickness of Above nickel is characterized by being 500A or more.
[Claim 6] The aforementioned Au-Sn alloy is the cementing material of the electric element according to claim 4 or 5 characterized by being physical gaseous-phase membrane formation.
[Claim 7] The claim 5 to which thickness of the aforementioned Au-Sn alloy is characterized by being 0.3-3 micrometers, or the cementing material of the electric element of any one publication of six.
[Claim 8] The aforementioned pedestal is the junction method of the claim 1 characterized by being constituted using the material of Au, nickel, Fe, or Cu in the field where the aforementioned electric element is joined, or the electric element any one publication of seven.
[Claim 9] The claim 1 characterized by the aforementioned electric element being a semiconductor laser element, or the junction method of the electric element any one publication of eight.
[Claim 10] The junction method of the electric element characterized by forming nickel layer in the aforementioned electrode, forming the solder layer containing Sn directly on this nickel layer in the method of joining the electrode of electric element to a pedestal, carrying out heating fusion of this solder layer, and joining the aforementioned electric element to the aforementioned pedestal.
[Claim 11] The junction method of the electric element which forms nickel layer and the solder layer containing Sn in the aforementioned electrode in the method of joining the electrode of electric element to a pedestal, respectively, carries out heating fusion of the aforementioned solder layer, is made to carry out counter diffusion of the above nickel and Sn, and is characterized by joining the aforementioned electric element to the aforementioned pedestal.
[Claim 12] The junction method of the electric element according to claim 10 or 11 characterized by forming the aforementioned nickel layer in thickness 500A or more.
[Claim 13] The claim 10 characterized by forming the aforementioned solder layer by the physical vapor growth which makes an alloy the source of vacuum evaporationo, or the junction method of the electric element any one publication of 12.
[Claim 14] The claim 10 characterized by forming the aforementioned solder layer by 0.3-3-micrometer thickness, or the junction method of the electric element any one publication of 13.
[Claim 15] the Au-Sn-nickel alloy which made Au the subject for the aforementioned solder layer -- forming -- heating melting of the aforementioned solder layer -- nickel -- 1.3wt(s)% to 10wt(s)% -- the junction method of the claim 10 characterized by forming the contained Au-Sn-nickel alloy, or the electric element any one publication of 14
[Claim 16] The aforementioned pedestal is the junction method of the claim 10 characterized by being constituted using the material of Au, nickel, Fe, or Cu in the field where the aforementioned electric element is joined, or the electric element any one publication of 15.
[Claim 17] The claim 10 characterized by the aforementioned electric element being a semiconductor laser element, or the junction method of the electric element any one publication of 16.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the cementing material and the junction method of electric element which solder electric element, such as a semiconductor laser element, to a pedestal.
[0002]
[Description of the Prior Art] When semiconductor devices, such as a semiconductor laser element, were conventionally soldered to pedestals, such as a gold-plated heat sink, and a stem, the circuit board, the forming pellet of eutectic solders, such as Au-Sn and Pb-Sn, was used. In the case of a forming pellet, from the reasons of the production method and handling, it is 100 micrometers of several 100 micrometerx numbers, and several 10 micrometers or more are required as thickness.
[0003] For this reason, a solder layer serves as an amount more than required, a position gap arises or the marginal part which upheaved around the semiconductor device is formed. In the case of a semiconductor laser element, the problem that this eminent solder layer becomes the obstacle of a laser beam occurs. There is a thing shown in JP,59-178736,A to solve this problem. In this thing, the thin film of the barrier electrode which prevents golden diffusion, and the solder material containing gold is prepared on the golden electrode of a semiconductor laser element without a forming pellet, and mounting with thin film solder is performed. Moreover, the same technology also as JP,6-69608,A is indicated.
[0004]
[Problem(s) to be Solved by the Invention] However, even if it makes a solder layer into a thin film, since there are few amounts of solder, when the wettability of a solder layer and a component side is bad, it does not connect partially and there is a problem that sufficient connection resilience and low connection resistance are not obtained. this invention is what took the example by the above-mentioned problem, and it aims at joining a semiconductor device to a plinth so that sufficient bond strength and the stable electrical installation may be obtained.
[0005]
[Means for Solving the Problem] Sn and nickel were congenial and this invention person etc. noted forming an intermetallic compound. As a drain electrode of a GaAs substrate, what carried out the laminating of nickel and the Au to the alloy of Au and germanium conventionally (this kind of notation is hereafter shown like Au-germanium/nickel/Au) is used. At this thing, if nickel thickness is thickened, it is supposed that contact resistance goes up and nickel thickness is used by about 200A. In this case, nickel is used as a barrier electrode which prevents diffusion of Au. Therefore, the vacuum evaporationo of the solder containing Sn was carried out using this thing, and it tried to solder it to plinths, such as a heat sink.
[0006] However, Au on nickel was spread in the solder layer, and the problem of reducing adhesion intensity and wettability occurred. Then, when this invention person etc. lost and soldered Au layer, wettability of solder is good and he came to be able to do by stabilizing powerful soldering of a bond strength. This is because the counter diffusion that nickel was spread in a solder layer and Sn in a solder layer was spread in nickel arose and adhesion intensity and wettability improved.
[0007] Moreover, although the cementing material which makes virtual junction temperature low and mitigates the heat damage to a semiconductor laser element needed to be selected in junction of a semiconductor laser element, when many things were examined also about this point and Au-Sn solder was used as a solder layer so that it may mention later, nickel was able to be spread in the Au-Sn layer, was able to make the Au-Sn-nickel alloy, and was able to make virtual junction temperature low.
[0008] this invention is made based on the above-mentioned examination, and the feature is a thing as indicated to the claim. Specifically, it is characterized by the following points. In invention according to claim 1, it is the cementing material (12) which joins the electrode (9) of electric element (1-9) to a pedestal (21), and it is the Au-Sn-nickel alloy which made Au the subject, and is characterized by the composition ratio of nickel being less than [more than 1.3wt%10wt%].
[0009] In invention according to claim 2, it is characterized by the composition ratio of Above nickel being more than 2.5wt% in the cementing material of electric element according to claim 1. In invention according to claim 3, it is characterized by the composition ratio of Above nickel being less than [more than 2wt%5wt%] in the cementing material of electric element according to claim 1. In invention according to claim 4, the aforementioned Au-Sn-nickel alloy is characterized by heating the laminated structure of the Au-Sn alloy (11) which made Au the subject, and nickel (10), and being formed in the cementing material of a claim 1 or the electric element of any one publication of three.
[0010] In invention according to claim 5, thickness of Above nickel is characterized by being 500A or more in the cementing material of electric element according to claim 4. In invention according to claim 6, the aforementioned Au-Sn alloy is characterized by being physical gaseous-phase membrane formation in the cementing material of electric element according to claim 4 or 5. In invention according to claim 7, thickness of the aforementioned Au-Sn alloy is characterized by being 0.3-3 micrometers in the cementing material of a claim 5 or the electric element of any one publication of six.
[0011] In invention according to claim 8, the aforementioned pedestal is characterized by being constituted using the material of Au, nickel, Fe, or Cu in the field where the aforementioned electric element is joined in the junction method of a claim 1 or the electric element any one publication of seven. According to invention according to claim 9, in the junction method of a claim 1 or the electric element any one publication of eight, it is characterized by the aforementioned electric element being a semiconductor laser element.

[0012] In invention according to claim 10, it is characterized by forming nickel layer (10) in the aforementioned electrode, forming the solder layer (11) containing Sn directly on this nickel layer, carrying out heating fusion of this solder layer, and joining the aforementioned electric element to the aforementioned pedestal in the method of joining the electrode (9) of electric element (1-9) to a pedestal (21).
[0013] In invention according to claim 11, in the method of joining the electrode (9) of electric element (1-9) to a pedestal (21), nickel layer (10) and the solder layer (11) containing Sn are formed in the aforementioned electrode, respectively, heating fusion of the aforementioned solder layer is carried out, counter diffusion of the above nickel and Sn is carried out, and it is characterized by joining the aforementioned electric element to the aforementioned pedestal.
[0014] In invention according to claim 12, it is characterized by forming the aforementioned nickel layer in thickness 500A or more in the junction method of electric element according to claim 10 or 11. In invention according to claim 13, it is characterized by forming the aforementioned solder layer by the physical vapor growth which makes an alloy the source of vacuum evaporationo in the junction method of a claim 10 or the electric element any one publication of 12.
[0015] In invention according to claim 14, it is characterized by forming the aforementioned solder layer by 0.3-3-micrometer thickness in the junction method of a claim 10 or the electric element any one publication of 13. the Au-Sn-nickel alloy which made Au the subject for the aforementioned solder layer in invention according to claim 15 in the junction method of a claim 10 or the electric element any one publication of 14 -- forming -- heating melting of the aforementioned solder layer -- nickel -- 1.3wt(s)% to 10wt(s)% -- it is characterized by forming the contained Au-Sn-nickel alloy
[0016] In invention according to claim 16, the aforementioned pedestal is characterized by being constituted using the material of Au, nickel, Fe, or Cu in the field where the aforementioned electric element is joined in the junction method of a claim 10 or the electric element any one publication of 15. In invention according to claim 17, it is characterized by the aforementioned electric element being a semiconductor laser element in the junction method of a claim 10 or the electric element any one publication of 16.
[0017] In addition, the sign in the above-mentioned parenthesis shows a correspondence relation with the concrete composition given in an example mentioned later.
[0018]
[Function and Effect of the Invention] According to invention according to claim 1 to 9, with the Au-Sn-nickel alloy which made Au the subject for the cementing material, since the composition ratio of nickel is made into less than [more than 1.3wt%10wt%], strong high junction can be performed by the low melting point, and, moreover, the increase in contact resistance can be suppressed.
[0019] Especially, according to invention according to claim 2, since the composition ratio of nickel is made more than 2.5wt%, the stable high bonding strength can be obtained. Moreover, according to invention according to claim 3, since the composition ratio of nickel is made into less than [more than 2wt%5wt%], the melting point can be made still lower. Moreover, according to invention according to claim 5, since thickness of nickel is made into 500A or more, a bond strength can be made high.
[0020] Moreover, since the solder layer is considered as physical gaseous-phase membrane formation, while according to invention according to claim 6 there is almost no change of the melting point to dispersion in thickness and being able to obtain the stable intensity, the stable electrical installation can be obtained and the flash of the solder more than required can be abolished further. Moreover, according to invention according to claim 7, since thickness of an Au-Sn alloy is set to 0.3-3 micrometers, a bond strength can be raised..
[0021] The solder layer which contains nickel layer and Sn in the electrode of electric element is formed, this solder layer is fused further, and it is made to join to a pedestal in invention of the junction method according to claim 10 to 17. Here, the counter diffusion that nickel in nickel layer is spread in a solder layer, and Sn in a solder layer is spread in nickel layer at the time of melting of a solder layer arises. Adhesion intensity and wettability can be raised according to this counter diffusion.
[0022]
[Example] Hereafter, the example which applied this invention to semiconductor laser is explained. A semiconductor laser element grows epitaxially on GaAs or an InP substrate, and prepares each active region during a crystal. Generally an n type substrate is used for a substrate. As a material system, a GaAs-AlGaAs system, an InGaAsP-InP system, an InGaP-InGaAlP system, etc. can be used. As the epitaxial growth method, solution layer epitaxial, a molecular beam epitaxy (MBE:molecular beamepitaxy), organic-metal gaseous-phase epitaxy (MOCVD:metal organic chemicalvapaor deposition), etc. can be used. As a barrier layer, it can consider as terrorism structure, quantum well structure, etc. to double.
[0023] The perspective diagram of a semiconductor laser element is shown in drawing 1 . On the n-GaAs substrate 1, the laminating of the n-GaAs buffer layer 2, the n-AlGaAs clad layer 3, the barrier layer 4 that consists of AlGaAs/GaAs multiplex quantum well structure, the p-AlGaAs clad layer 5, and the p-GaAs layer 6 is carried out to order, and the barrier layer 4 - the p-GaAs layer 6 are formed in the shape of a mesa. Moreover, an insulator layer 7 has a window part on the upper surface of the n-AlGaAs clad layer 3 and the mesa section, and is formed in it, and p type electrode (up electrode) 8 is formed on this insulator layer 7.
[0024] This p type electrode 8 forms membranes in predetermined thickness by electron beam evaporation, the spatter, etc., and is formed. As a p type electrode 8, although Au-Zn/Au, Cr/Au, Mo/Au, Ti/Pt/Au, etc. can be used, as long as it can take an ohmic contact, other materials are sufficient. n type electrode (lower electrode) 9 which consists of Au-germanium is formed in the rear face of the n-GaAs substrate 1, and the cementing material which consists of a nickel layer 10 and a solder layer 11 is formed in the front face of n type electrode 9.
[0025] The semiconductor laser element constituted as mentioned above is joined to a heat sink, other semiconductor substrates, the circuit board, etc. This mounting method is explained. Two or more semiconductor laser elements shown in drawing 1 are put on the heat sink 21 shown in drawing 2 , and let them be laminating types. A sign 22 shows this. In this case, the cementing material of an upper semiconductor laser element is located on p type electrode of a lower semiconductor laser element.
[0026] The heat sink 21 consists of Cu, Fe, etc., and, as for the front face, the metal with high ******, such as nickel and Au, is formed of plating or vacuum evaporationo, the spatter, etc. Alignment of two or more semiconductor laser elements is

carried out, respectively, and it accumulates on a heat sink 21. At this time, since that as which this serves as the pressurization section at the time of heater heating tends to take out position precision using a vacuum pincette, conveyance of a chip is desirable.

[0027] As the semiconductor laser element accumulated on the heat sink 21 does not shift, it pressurizes, and it heats so that the solder layer 11 of each semiconductor laser element may be melted and it may be made to paste up. After becoming the temperature into which solder melts, it is left in the state several minutes from several seconds, and it cools after that. as for the heating method, a position gap does not produce a heat sink and the whole semiconductor laser chip -- as -- fixing -- the whole -- constant temperature -- although there is the method of heating at a heater etc. from the rear face of the method of heating in a layer etc., or a heat sink, the ease of the equipment work method to the latter is more desirable

[0028] In order to take semiconductor laser and electric contact to the degree of the above-mentioned die bond, bonding of an up electrode and the drive circuit wiring is carried out with the wires 23, such as Au and Pt. Then, can enclosure is performed if needed and it considers as the finished product of semiconductor laser. Formation of the above-mentioned n type electrode 9, the nickel layer 10, and the solder layer 11 and junction to a heat sink 21 are explained. The composition of this portion is shown in drawing 3 .

[0029] In order that n type electrode 9 formed in the rear face of the n-GaAs substrate 1 may form an ohmic electrode, Au-Zn/Au, Cr/Au, Ti/Pt/Au, Au-germanium/nickel/Au, Au-Sn/Au, etc. and these alloy cascade screens are used as an electrode material. This is formed in the rear face of the n-GaAs substrate 1 by predetermined thickness by the electron beam evaporation which is a vacuum deposition method, resistance heating vacuum evaporationo, the spatter, etc.

[0030] Next, the nickel layer 10 is formed on n type electrode 9 by the same method. Then, the alloy which contains Sn, such as Au-Sn and Pb-Sn, as a solder layer 11 is formed on the nickel layer 10. About the formation method of a solder layer, it mentions later. Thus, the solder layer 11 containing 10/of produced 9/nickel layers Sn of electrodes is put on the heat sink 21 which gave metal plating 21a, such as nickel and Au, pressurization and heating are performed, and a semiconductor laser element is mounted on a heat sink 21 by fusing the solder layer 11 and cooling.

[0031] Although there are Au-Sn, Au-Si, In, In-Pb, Pb-Sn, Au-Pb, Au-germanium, etc. in solder material, the strong junction of a bond strength with sufficient wettability is obtained by soldering by carrying out the laminating of the solder and nickel containing Sn, such as Au-Sn and Pb-Sn. It is effective when Au-Sn is especially used for solder material. The duty of the nickel layer 10 has solder material, the role of the barrier electrode from which it is made for an electrode not to start counter diffusion, and the duty that is spread in a solder layer and improves the wettability of solder. With a GaAs semiconductor, using Au for the best layer of an electrode in many cases, Au is diffused at low temperature in the solder layer which is activity and will connect and to carry out, and the stability of contact becomes bad. For this reason, the barrier electrode is required, and when especially an electrode is the alloy of Au and Au, it is effective.

[0032] At least 200A of thickness of nickel as a barrier electrode is required. Less than [this], it becomes an island-like film and the duty of a barrier metal is not achieved. nickel thickness dependency of the intensity of the glue line at the time of having formed 1000A of Au-germanium electrodes to the 0.5mmx0.5mm n-GaAs substrate, carrying out the laminating of the nickel/Au-Sn (Au and Sn being the thing of eutectic composition) on it, mounting in drawing 4 , and carrying out a vibration test to it is shown. This vibration test is JIS. It carried out on C7022A-10, Conditions D, the vibration frequency range of 10-2000Hz, acceleration 20G, direction 3 direction, and the conditions for time 48 minutes. In addition, the thickness of the Au-Sn solder layer 11 presupposed that it is fixed 1.5 micrometers.

[0033] The bond strength is large as the thickness of the nickel layer 10 becomes thick, and there is no difference in intensity at 1000A or more of thickness. In 1000A or more of thickness, since a substrate breaks during an examination, it is thought that intensity is more than this. Moreover, peeling arises [thickness] in 200A and sufficient bond strength is not obtained. If there are 500 or more gves of bond strengths, there is intensity of enough and it is necessary to bear various reliability trials, to accumulate and to make nickel thickness into 500A or more.

[0034] Next, how to form the solder layer 11 is explained. It tried to carry out the laminating of the component of alloys, such as Au-Sn, and to create it on the occasion of formation of the solder layer 11. In this case, the design of a composition ratio can be performed freely and management of vacuum evaporationo material is also easy for it. However, when the thickness of each class differs in this, it becomes a composition gap immediately. Usually, as for the composition ratio of solder, it is common to use eutectic composition, and the melting point becomes high when a composition gap is caused. Thus, if the melting point changes, you have to change the conditions of mounting into whenever [the]. If it carries out on the same conditions, even if solder material will not melt or it will melt, the stable adhesion intensity is no longer obtained after mounting, without fully melting.

[0035] Then, it examined forming alloys, such as Au-Sn, Pb-Sn, In, In-Pb, Au-Si, and Au-Pb, by the vapor growth as a solder layer 11. That is, the solder layer 11 is formed by the physical vapor growth which made the above-mentioned alloy the source of vacuum evaporationo. Here, a physical vapor growth calls it Physical Vapor Deposition (PVD), does not use a chemical reaction, but is the method of forming a thin film using a physical change, and has vacuum evaporationo, a spatter, ion plating, etc. If a physical vapor growth is put in another way, the material itself formed on a substrate will reach a substrate in the state of a steam or a cluster, and a thin film and a bird clapper will be said. On the other hand, as a method using the chemical reaction, there is the ChemicalVapor Deposition (CVD) method, this carries out the decomposition reaction of the raw material using energy, such as heat, plasma, and light, into a gaseous phase, it becomes a thin film using a chemical reaction, and, as for PVD, the principles of membrane formation differ.

[0036] Thus, by forming the solder layer 11, even if metaphor thickness varies, there is always almost no change of the melting point, and the above problems were able to be solved. As the membrane formation method by the vapor growth, electron beam evaporation, resistance heating vacuum evaporationo, a spatter, etc. can be used. Since some raw materials and composition ratios shift according to the difference of the vapor pressure of an alloy in electron beam evaporation and resistance heating vacuum evaporationo among these, it is desirable to use a spatter as the membrane formation method. In addition, since a composition ratio is decided by vapor pressure even if there will be no change of a raw material and a composition ratio and it will not carry out the vacuum evaporationo of all the raw materials, if most raw materials have been flown altogether when electron beam evaporation and resistance heating vacuum evaporationo are used, membranous composition ratios do not differ for every batch.

[0037] Although there was a problem that the upheaval object by superfluous solder might sometimes hide to a luminous layer, and served as hindrance of an optical output in the conventional thing which used the forming pellet as a solder layer As mentioned above, by making the solder layer 11 into the thin film by gaseous layer growth, the flash of the solder more than required was lost and the strong junction of the adhesion intensity obtained and stabilized of the solder layer of the good composition ratio of repeatability was attained.
[0038] Next, the thickness of the above-mentioned solder layer 11 is explained. Although the flash of the solder more than required was lost by making a solder layer into the thin film by gaseous layer growth, when carrying out the laminating of two or more semiconductor laser elements as mentioned above and solder layer thickness is thick, there is a problem of covering a luminous layer by the flash of solder. Moreover, when soldering the electrode of the side near a luminous layer, in [the case like the example 2 of creation mentioned later], the same problem occurs. On the contrary, when a solder layer is thin, there is a problem that adhesion intensity is weak.
[0039] The solder layer thickness when mounting a 0.5mmx0.5mm semiconductor laser element in the gold-plated copper heat sink at drawing 5 and the relation of adhesion intensity are shown. Adhesion intensity is so strong that the thickness of a solder layer becomes thick, and does not have a strong difference at 1 micrometers or more. By 1 micrometers or more, since a substrate breaks, thickness is considered that there is intensity more than this. If there are 500 or more gves of bond strengths, it turns out that there is intensity of enough and various reliability trials can be borne. Therefore, there should just be 3000A or more of thickness of a solder layer.
[0040] Solder layer thickness has the surface roughness and relation of an adhesion side, and used Ra=1000A for this measurement this time. Generally, the thickness of a solder layer was understood that it needs to be thicker than surface roughness and about 3 times [of surface roughness] thickness is more nearly required than this result. The surface roughness Ra=500-2500A thing of the adhesion side of the stem used for mounting is used. Since, as for the surface roughness of a stem, the 1000A thing is usually used, solder layer thickness is at least 3000A or more need, and its 5000A or more is desirably good.
[0041] Although the thickness of a solder layer has so strong that it becomes thick adhesion intensity, if it becomes thick, as for a solder layer, ****** will pose a problem. When more than one are mounted especially, the flash of a solder layer will cover a luminous layer. Furthermore, if thickness becomes thick, membrane formation time will also become long, and problems, like the amount of vacuum evaporationo material also increases arise. By Atsushi whose solder layer is 1 micrometer, although there is almost nothing, the flash of a solder layer will be protruded in addition to the rear face of a chip, if it becomes the thickness beyond it. When solder layer thickness was made larger than 3 micrometers, solder was attached to the luminescence side side, and in 4 micrometers or more, time generated the luminous layer with the wrap. Therefore, the thickness of a solder layer has good 3 micrometers or less.
[0042] Therefore, strong junction of adhesion intensity is attained by setting thickness of the solder layer 11 to 0.3-3 micrometers. Moreover, the optical output by which adhesion intensity was stabilized strongly is obtained, without the solder of the laminating section covering a luminous layer, when carrying out the laminating of two or more semiconductor laser. The example of creation of the semiconductor device using the above-mentioned solder layer 11 is shown.
(Example 1 of creation) The GaAs/AlGaAs system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the n type electrode side. At this time, the three-piece laminating of the semiconductor laser element was carried out. 1000A of Au88wt%-Gewt12% was formed as an n type electrode, and 1000A and 1 micrometer of Au-Sn solder were prepared for nickel on it. At this time, Au-germanium/nickel formed membranes using E.B. vacuum evaporationo, and the solder layer formed membranes by the spatter. Size of a semiconductor laser element was set to 500x600x110 micrometers. This element was placed in piles on [three] the copper heat sink which gold-plated, and it mounted by the heating temperature of 340 degrees C, and 60g of pressurization loads. The mounted element does not have the flash of a solder layer, either and solder did not cover a luminous layer. In this element, when three directions were performed for the variable frequency of 10-2000Hz, 20 G/sec2, and 48 minutes, it was changeless in any way examination before. When the bond strength of this element was measured with the SHIEA circuit tester, the intensity of 1 or more kgves was obtained.
(Example 2 of creation) The InGaP-InGaAlP system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the p type electrode side. Ti1000A, Pt2000A, and Au3000A were formed as a p type electrode, respectively, and 800A and 0.8 micrometers of Au-Sn solder were prepared for nickel on it. E.B. vacuum evaporationo was used for membrane formation at this time. Size of a semiconductor laser element was set to 600x700x110 micrometers. Although p type electrode was soldered, the good optical output was obtained without a solder layer covering a barrier layer. Furthermore, adhesion intensity also acquired the value of 1 or more kgves, and the stable contact was obtained.
(Example 3 of creation) The GaAs field-effect transistor element was produced on the half-insulation GaAs substrate, and it soldered to the printed circuit board which gold-plated. 2 micrometers of Au-Sn solder were prepared in the substrate rear face. At this time, membranes were formed by the spatter. Element size is 500x600x180 micrometers. This element was mounted by the heating temperature of 360 degrees C, and 100g of pressurization loads. When the bond strength of this element was measured with the SHIEA circuit tester, the intensity of 1 or more kgves was obtained.
[0043] Next, the cementing material using solder is explained. Although it is effective to enlarge the set points, such as virtual junction temperature, a pressurization pressure at the time of junction, and pressurization time, in order to raise wettability or a bonding strength when joining a semiconductor laser element which was mentioned above to a heat sink, As in GaAs used as a material of a semiconductor laser element increases the heat damage to which sublimation temperature gives a high virtual junction temperature to an element for a low reason. Moreover, the mechanical damage which also gives a high pressurization pressure and long pressurization time to a luminous layer is increased.
[0044] Therefore, in junction of a semiconductor laser element, it is necessary to select the cementing material which makes virtual junction temperature low and mitigates the heat damage to a semiconductor laser element. this invention person etc. found out that the low melting point was acquired rather than an Au80wt%-Sn20wt% pellet, when it considered as the laminated structure of nickel/(Au80wt%-Sn20wt%), using Au-Sn system solder as a solder layer 11, as a result of examining many things for the above-mentioned point. nickel diffuses this in an Au-Sn layer, and depends it on making a Au-Sn-nickel

alloy.

[0045] Based on this, nickel thickness was changed, nickel concentration which carries out thermal diffusion to Au80wt%-Sn20wt% Naka was changed, and the state diagram was created. The result is shown in drawing 6 . In this drawing, L and S show the liquid phase and solid phase, respectively, and alpha and beta show the solid solution of Au-Sn-nickel, respectively. Therefore, it expresses that (L+alpha) and (L+beta) are the mixed state of the liquid phase and solid phase, respectively. The thickness of nickel when setting Au80wt%-Sn20wt% thickness to 1.5 micrometers in nickel/(Au80wt%-Sn20wt%) layer structure is shown in an upper horizontal axis.

[0046] From this state diagram, a (Au80wt%-Sn20wt%)-nickel alloy becomes lower than the melting point of an Au80wt%-Sn20wt% pellet, when the amount of nickel increases, and when the composition ratio (weight ratio of nickel to the total weight of a cementing material) of nickel is made into 1.3wt(s)%, about 10 degrees C of melting points become low. Furthermore, the amount of nickel is increased, when it considers as about 3wt%, the melting point becomes low most, and compared with an Au80wt%-Sn20wt% pellet, it falls by 25 degrees C or more. Therefore, virtual junction temperature can be reduced by 25 degrees C or more to having joined by the melting point of a conventional Au80wt%-Sn20wt% pellet, and the heat damage to an element can be reduced.

[0047] in addition -- what [not only] nickel diffused the above-mentioned effect and the effect mentioned later in the Au-Sn layer, it depends on making a Au-Sn-nickel alloy, and was made into the laminated structure of nickel/(Au80wt%-Sn20wt%) but a (Au80wt%-Sn20wt%)-nickel alloy layer -- also carrying out -- it can obtain similarly The composition ratio of nickel of Au80wt%-Sn20wt% Naka and the relation of a bonding strength are shown in drawing 7 . This drawing shows being saturated with composition beyond 2.5wt%, although it becomes strong as the composition ratio of a bonding strength of nickel increases. In the experiment, it is checked that intensity is measured to 9.5wt% and there is sufficient intensity.

[0048] although nickel composition ratio exfoliates in respect of adhesion of a heat sink and solder with the 0.7wt(s)% conventional structure in a bonding-strength examination -- nickel composition ratio -- by the plane of composition, it does not exfoliate but the element section joined is destroyed more than at 1.3wt% Since it turns out that sufficiently various kinds of reliability trials can be borne if a bonding strength is 500 or more gves, the bonding strength stabilized when nickel composition ratio was more than 1.3wt% is obtained.

[0049] In addition, in drawing 7 , a 50g pressurization load is added, in the case of beyond 2.5wt%, it does not pressurize, and 1.7wt% of case joins only by the self-weight of an element nickel composition ratio 1.3wt(s)%. Therefore, bonding strength only with the sufficient self-weight of an element can be obtained by making nickel composition ratio more than 2.5wt%. From these results, the melting point of solder falls, a bonding strength is still stronger and by adding nickel to Au80wt%-Sn20wt% Naka shows a bird clapper. The composition ratio of nickel is good, and if it takes wettability and a bonding strength into consideration, more than its 1.3wt% is desirable. [1wt% to 10wt(s)% to which the melting point falls by 10 degrees C or more of] the composition ratio of nickel since the low melting point is acquired most and the composition after solder solidification is kept uniform in the long run -- 3wt(s)% in a 3 yuan system -- especially 2wt(s)% to 5wt(s)% of order is desirable

[0050] In addition, if the composition ratio of nickel becomes 10% or more when nickel composition ratio is made to increase by thickening nickel thickness on Au-germanium, the intermetallic compound of Sn-nickel is generated, and since the intermetallic compound is an insulator, the resistance of a joint will become high. Therefore, if the increase in resistance of a joint is taken into consideration, it is desirable to make the composition ratio of nickel into less than 10%.

[0051] Thus, a cementing material is the solder material which contains nickel of a constant rate in an Au-Sn eutectic solder, and when a plinth front face was Au layer, it came to be able to do by stabilizing the strong junction of a bond strength with sufficient wettability, when joining a semiconductor laser element to a plinth etc. In addition, also in the thing of the laminated structure of above-mentioned nickel/(Au80wt%-Sn20wt%), it is desirable to make thickness of nickel into 500A or more, as mentioned above, and to set thickness of an Au-Sn alloy solder layer to 0.3-3 micrometers.

[0052] The example of creation using the above-mentioned cementing material is explained.

(Example 4 of creation) The GaAs/AlGaAs system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the n type electrode side. 0.1 micrometers was formed for Au88wt%-germanium12% as an n type electrode, and 0.1 micrometers and 1.5 micrometers of Au-Sn solder were prepared for nickel on it. At this time, (Au-germanium)/nickel formed membranes using E.B. vacuum evaporationo, and the solder layer formed membranes by the spatter. Size of a semiconductor laser element was set to 500x600x110 micrometers. This element was placed on the copper heat sink which gold-plated, and it mounted, without adding the heating temperature of 340 degrees C, and a pressurization load. In this element, when the vibration test of three directions was performed for variable frequency [of 10-2000Hz], and 20 G or 48 minutes, it was changeless in any way examination before. When the bonding strength of this element was measured by the circuit tester, the intensity of about 1kg was obtained. The composition ratio of the cementing material at this time was Au77.3wt%-Sn19.3wt%-nickel3.4wt%.

(Example 5 of creation) The InGaP-InGaAlP system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the p type electrode side. As a p type electrode, 0.1 micrometers was formed for Ti, 0.2 micrometers and 0.3 micrometers of Au(s) were formed for Pt, and 0.1 micrometers and 1.0 micrometers of Au-Sn solder were prepared for nickel on it. E.B. vacuum evaporationo was used for membrane formation at this time. Size of a semiconductor laser element was set to 600x700x110 micrometers. Although p type electrode was soldered by the heating temperature of 340 degrees C, and 30g of pressurization loads, the good optical output was obtained without a solder layer covering a barrier layer. Furthermore, the bonding strength also acquired the value of 1 or more kgves, and the stable contact was obtained. The composition ratio of the cementing material at this time was Au76wt%-Sn19wt%-nickel5wt%.

(Example 6 of creation) n type electrode side of a top semiconductor laser element was soldered to the upper surface by the side of p type electrode of a semiconductor laser element, and it considered as the laminated structure. As a p type electrode, 0.04 micrometers and Pt layer were formed for Cr, and 0.5 micrometers was formed for 0.1 micrometers and Au layer. 0.1 micrometers of Au88wt%-Gewt12% were formed as an n type electrode, and 0.1 micrometers and 1.5 micrometers of Au-Sn solder were prepared for nickel on it. At this time, (Au-germanium)/nickel formed membranes using E.B. vacuum evaporationo, and the solder layer formed membranes by the spatter. Size of a semiconductor laser element was set to

600x700x110 micrometers. n type electrode was soldered on p type electrode by the heating temperature of 340 degrees C, and 30g of pressurization loads. When the bond strength was measured with the SHIEA circuit tester, the intensity of 500 or more kgves was obtained. At this time, the solder layer obtained the good optical output [be / nothing], alias a wrap, for the barrier layer. Moreover, the output was able to be increased by making a semiconductor laser element into a laminated structure. The composition ratio of the cementing material at this time was Au77.3wt%-Sn19.3wt%-nickel3.4wt%.
[0053] Although the heat sink which plated Au, nickel, etc. as a plinth was shown, you may make it solder a semiconductor device for plinths, such as Fe and Cu, in the above-mentioned various examples. Moreover, although the thing for a semiconductor laser element was explained as a semiconductor device, this invention is applicable also to other semiconductor devices. In this case, it is applicable also to what uses a short key electrode in addition to an ohmic electrode. As a material of this short key electrode, it can consider as aluminum, Pt, Au, Ta, Cr, W, Mo, Ti, Cu, Ag, and Ai-Si.
[0054] Moreover, this invention is applicable also to electric element, such as a chip resistor and a chip capacitor, in addition to a semiconductor device. Next, other above-mentioned examples of application of a Au-Sn-nickel cementing material are explained.
(Example 7 of creation) When the drive IC 30 of a liquid crystal display or electroluminescence (henceforth EL) display is mounted on a glass substrate 31 and it connects with a conductor (electrode) 32, there is a thing of composition of being shown in (a) shown in drawing 8 , (b), and (c). That for which (a) used the mounting pad 33 and the wire 34, the thing for which (b) used the bump 36, and (c) use the beam lead 37. the above-mentioned Au-Sn-nickel cementing material -- in (a), it is used for the cementing material of the mounting section 35 and the mounting pad 33 as the beam lead 37 as a bump 36 by (b) at (c)
[0055] Hereafter, the example which mounts drive IC 30 in an EL panel using the composition of (a) is explained. In order to produce an EL panel, first, on the glass substrate 31, as a transparent electrode, 0.1 micrometers was formed and ITO was processed on the stripe. Next, 1 micrometer of CaS:Eu was formed by the E.B. vacuum deposition as a luminous layer. Next, it is SiO2 as an insulating layer. 0.3 micrometers was formed by RF and P-CVD, subsequently 0.15 micrometers of aluminum were formed as a back plate 32, and patterning was performed to the predetermined pattern. Next, as the mounting pad 33 and an ejection pad of wiring, 0.1 micrometers of nickel were formed first, subsequently 0.5 micrometers of Au(s) were formed, and patterning was performed. Membrane formation was performed by the spatter. Finally, the glass substrate 31 was joined by the epoxy resin, the silicone oil was enclosed, the protective layer was formed, and it considered as the EL panel.
[0056] Subsequently, in order to join drive IC 30 to a glass substrate 31, 0.2 micrometers of nickel were formed at the rear face of drive IC 30, and, subsequently (Au80wt%-Sn20wt%), 2 micrometers formed membranes at it. All performed membrane formation by the spatter. This was joined to the mounting pad 35 in 350 degrees C and 80g of pressurization loads. On the other hand, the ejection pad of EL panel wiring and the ejection pad of drive IC 30 were wired using the Au wire 34. Thus, the drive IC 30 was mounted by the bonding strength stabilized on the glass substrate 31. The composition ratio of the cementing material at this time was Au76wt%-Sn19wt%-nickel5wt%.
(Example 8 of creation) To drawing 9 , it is SiNX. The example which joined the Si substrate 42 and the GaAs/AlGaAs system semiconductor laser element 40 which prepared the optical waveguide using the bump 44 is shown. The (Au78wt%-Sn19.5wt%)-nickel2.5wt% cementing material was used as a bump 44, four things of 40 micrometers of diameters of a bump were used, and the semiconductor laser element 40 was mounted in the Si substrate 42. The bump 44 formed on the Au pad 43 on the Si substrate 42. Thickness could be 0.1 micrometers, 0.02 micrometers, and 0.4 micrometers at the rear-face electrode 41 of the semiconductor laser element 40 using (Au-germanium)/nickel/Au, respectively. the semiconductor laser element 40 -- a bump 44 -- putting -- the substrate whole -- 360-degree C constant temperature -- it joined by performing a reflow in a layer Thus, the semiconductor laser element 40 was mounted on the Si substrate 42.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] this invention relates to the cementing material and the junction method of electric element which solder electric element, such as a semiconductor laser element, to a pedestal.

[Translation done.]

PRIOR ART

[Description of the Prior Art] When semiconductor devices, such as a semiconductor laser element, were conventionally soldered to pedestals, such as a gold-plated heat sink, and a stem, the circuit board, the forming pellet of eutectic solders, such as Au-Sn and Pb-Sn, was used. In the case of a forming pellet, from the reasons of the production method and handling, it is 100 micrometers of several 100 micrometerx numbers, and several 10 micrometers or more are required as thickness.
[0003] For this reason, a solder layer serves as an amount more than required, a position gap arises or the edge which upheaved around the semiconductor device is formed. In the case of a semiconductor laser element, the problem that this eminent solder layer becomes the obstacle of a laser beam occurs. There is a thing shown in JP,59-178736,A to solve this problem. In this thing, the thin film of the barrier electrode which prevents golden diffusion, and the solder material containing gold is prepared on the golden electrode of a semiconductor laser element without a forming pellet, and mounting with thin film solder is performed. Moreover, the same technology also as JP,6-69608,A is indicated.

[Translation done.]

EFFECT OF THE INVENTION

[Function and Effect of the Invention] According to invention according to claim 1 to 9, with the Au-Sn-nickel alloy which made Au the subject for the cementing material, since the composition ratio of nickel is made into less than [more than 1.3wt%10wt%], strong high junction can be performed by the low melting point, and, moreover, the increase in contact resistance can be suppressed.
[0019] Especially, according to invention according to claim 2, since the composition ratio of nickel is made more than 2.5wt%, the stable high bonding strength can be obtained. Moreover, according to invention according to claim 3, since the composition ratio of nickel is made into less than [more than 2wt%5wt%], the melting point can be made still lower. Moreover, according to invention according to claim 5, since thickness of nickel is made into 500A or more, a bond strength can be made high.
[0020] Moreover, since the solder layer is considered as physical gaseous-phase membrane formation, while according to invention according to claim 6 there is almost no change of the melting point to dispersion in thickness and being able to obtain the stable intensity, the stable electrical installation can be obtained and the flash of the solder more than required can be abolished further. Moreover, according to invention according to claim 7, since thickness of an Au-Sn alloy is set to 0.3-3 micrometers, a bond strength can be raised..
[0021] The solder layer which contains nickel layer and Sn in the electrode of electric element is formed, this solder layer is fused further, and it is made to join to a pedestal in invention of the junction method according to claim 10 to 17. Here, the counter diffusion that nickel in nickel layer is spread in a solder layer, and Sn in a solder layer is spread in nickel layer at the time of melting of a solder layer arises. Adhesion intensity and wettability can be raised according to this counter diffusion.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, even if it makes a solder layer into a thin film, since there are few amounts of solder, when the wettability of a solder layer and a component side is bad, it does not connect partially and there is a problem that sufficient connection resilience and low connection resistance are not obtained. this invention is what took the example by the above-mentioned problem, and it aims at joining a semiconductor device to a plinth so that sufficient bond strength and the stable electrical installation may be obtained.
[0005]

[Translation done.]

MEANS

[Means for Solving the Problem] Sn and nickel were congenial and this invention person etc. noted forming an intermetallic compound. As a drain electrode of a GaAs substrate, what carried out the laminating of nickel and the Au to the alloy of Au and germanium conventionally (this kind of notation is hereafter shown like Au-germanium/nickel/Au) is used. At this thing, if nickel thickness is thickened, it is supposed that contact resistance goes up and nickel thickness is used by about 200A. In this case, nickel is used as a barrier electrode which prevents diffusion of Au. Therefore, the vacuum evaporationo of the solder containing Sn was carried out using this thing, and it tried to solder it to plinths, such as a heat sink.
[0006] However, Au on nickel was spread in the solder layer, and the problem of reducing adhesion intensity and wettability occurred. Then, when this invention person etc. lost and soldered Au layer, wettability of solder is good and he came to be able to do by stabilizing powerful soldering of a bond strength. This is because the counter diffusion that nickel was spread in a solder layer and Sn in a solder layer was spread in nickel arose and adhesion intensity and wettability improved.
[0007] Moreover, although the cementing material which makes virtual junction temperature low and mitigates the heat damage to a semiconductor laser element needed to be selected in junction of a semiconductor laser element, when many things were examined also about this point and Au-Sn solder was used as a solder layer so that it may mention later, nickel was able to be spread in the Au-Sn layer, was able to make the Au-Sn-nickel alloy, and was able to make virtual junction temperature low.
[0008] this invention is made based on the above-mentioned examination, and the feature is a thing as indicated to the claim. Specifically, it is characterized by the following points. In invention according to claim 1, it is the cementing material (12) which joins the electrode (9) of electric element (1-9) to a pedestal (21), and it is the Au-Sn-nickel alloy which made Au the subject, and is characterized by the composition ratio of nickel being less than [more than 1.3wt%10wt%].
[0009] In invention according to claim 2, it is characterized by the composition ratio of Above nickel being more than 2.5wt% in the cementing material of electric element according to claim 1. In invention according to claim 3, it is characterized by the composition ratio of Above nickel being less than [more than 2wt%5wt%] in the cementing material of electric element according to claim 1. In invention according to claim 4, the aforementioned Au-Sn-nickel alloy is characterized by heating the laminated structure of the Au-Sn alloy (11) which made Au the subject, and nickel (10), and being formed in the cementing material of a claim 1 or the electric element of any one publication of three.
[0010] In invention according to claim 5, thickness of Above nickel is characterized by being 500A or more in the cementing material of electric element according to claim 4. In invention according to claim 6, the aforementioned Au-Sn alloy is characterized by being physical gaseous-phase membrane formation in the cementing material of electric element according to claim 4 or 5. In invention according to claim 7, thickness of the aforementioned Au-Sn alloy is characterized by being 0.3-3 micrometers in the cementing material of a claim 5 or the electric element of any one publication of six.
[0011] In invention according to claim 8, the aforementioned pedestal is characterized by being constituted using the material of Au, nickel, Fe, or Cu in the field where the aforementioned electric element is joined in the junction method of a claim 1 or the electric element any one publication of seven. According to invention according to claim 9, in the junction method of a claim 1 or the electric element any one publication of eight, it is characterized by the aforementioned electric element being a semiconductor laser element.
[0012] In invention according to claim 10, it is characterized by forming nickel layer (10) in the aforementioned electrode, forming the solder layer (11) containing Sn directly on this nickel layer, carrying out heating fusion of this solder layer, and joining the aforementioned electric element to the aforementioned pedestal in the method of joining the electrode (9) of electric element (1-9) to a pedestal (21).
[0013] In invention according to claim 11, in the method of joining the electrode (9) of electric element (1-9) to a pedestal (21), nickel layer (10) and the solder layer (11) containing Sn are formed in the aforementioned electrode, respectively, heating fusion of the aforementioned solder layer is carried out, counter diffusion of the above nickel and Sn is carried out, and it is characterized by joining the aforementioned electric element to the aforementioned pedestal.
[0014] In invention according to claim 12, it is characterized by forming the aforementioned nickel layer in thickness 500A or more in the junction method of electric element according to claim 10 or 11. In invention according to claim 13, it is characterized by forming the aforementioned solder layer by the physical vapor growth which makes an alloy the source of vacuum evaporationo in the junction method of a claim 10 or the electric element any one publication of 12.
[0015] In invention according to claim 14, it is characterized by forming the aforementioned solder layer by 0.3-3-micrometer thickness in the junction method of a claim 10 or the electric element any one publication of 13. the Au-Sn-nickel alloy which made Au the subject for the aforementioned solder layer in invention according to claim 15 in the junction method of a claim 10 or the electric element any one publication of 14 -- forming -- heating melting of the aforementioned solder layer -- nickel -- 1.3wt(s)% to 10wt(s)% -- it is characterized by forming the contained Au-Sn-nickel alloy
[0016] In invention according to claim 16, the aforementioned pedestal is characterized by being constituted using the material of Au, nickel, Fe, or Cu in the field where the aforementioned electric element is joined in the junction method of a claim 10 or the electric element any one publication of 15. In invention according to claim 17, it is characterized by the aforementioned electric element being a semiconductor laser element in the junction method of a claim 10 or the electric

element any one publication of 16.
[0017] In addition, the sign in the above-mentioned parenthesis shows a correspondence relation with the concrete composition given in an example mentioned later.

[Translation done.]

EXAMPLE

[Example] Hereafter, the example which applied this invention to semiconductor laser is explained. A semiconductor laser element grows epitaxially on GaAs or an InP substrate, and prepares each active region during a crystal. Generally an n type substrate is used for a substrate. As a material system, a GaAs-AlGaAs system, an InGaAsP-InP system, an InGaP-InGaAlP system, etc. can be used. As the epitaxial growth method, solution layer epitaxial, a molecular beam epitaxy (MBE:molecular beamepitaxy), organic-metal gaseous-phase epitaxy (MOCVD:metal organic chemicalvapaor deposition), etc. can be used. As a barrier layer, it can consider as terrorism structure, quantum well structure, etc. to double.
[0023] The perspective diagram of a semiconductor laser element is shown in drawing 1 . On the n-GaAs substrate 1, the laminating of the n-GaAs buffer layer 2, the n-AlGaAs clad layer 3, the barrier layer 4 that consists of AlGaAs/GaAs multiplex quantum well structure, the p-AlGaAs clad layer 5, and the p-GaAs layer 6 is carried out to order, and the barrier layer 4 - the p-GaAs layer 6 are formed in the shape of a mesa. Moreover, an insulator layer 7 has a window part on the upper surface of the n-AlGaAs clad layer 3 and the mesa section, and is formed in it, and p type electrode (up electrode) 8 is formed on this insulator layer 7.
[0024] This p type electrode 8 forms membranes in predetermined thickness by electron beam evaporation, the spatter, etc., and is formed. As a p type electrode 8, although Au-Zn/Au, Cr/Au, Mo/Au, Ti/Pt/Au, etc. can be used, as long as it can take an ohmic contact, other materials are sufficient. n type electrode (lower electrode) 9 which consists of Au-germanium is formed in the rear face of the n-GaAs substrate 1, and the cementing material which consists of a nickel layer 10 and a solder layer 11 is formed in the front face of n type electrode 9.
[0025] The semiconductor laser element constituted as mentioned above is joined to a heat sink, other semiconductor substrates, the circuit board, etc. This mounting method is explained. Two or more semiconductor laser elements shown in drawing 1 are put on the heat sink 21 shown in drawing 2 , and let them be laminating types. A sign 22 shows this. In this case, the cementing material of an upper semiconductor laser element is located on p type electrode of a lower semiconductor laser element.
[0026] The heat sink 21 consists of Cu, Fe, etc., and, as for the front face, the metal with high ******, such as nickel and Au, is formed of plating or vacuum evaporationo, the spatter, etc. Alignment of two or more semiconductor laser elements is carried out, respectively, and it accumulates on a heat sink 21. At this time, since that as which this serves as the pressurization section at the time of heater heating tends to take out position precision using a vacuum pincette, conveyance of a chip is desirable.
[0027] As the semiconductor laser element accumulated on the heat sink 21 does not shift, it pressurizes, and it heats so that the solder layer 11 of each semiconductor laser element may be melted and it may be made to paste up. After becoming the temperature into which solder melts, it is left in the state several minutes from several seconds, and it cools after that. as for the heating method, a position gap does not produce a heat sink and the whole semiconductor laser chip -- as -- fixing -- the whole -- constant temperature -- although there is the method of heating at a heater etc. from the rear face of the method of heating in a layer etc., or a heat sink, the ease of the equipment work method to the latter is more desirable
[0028] In order to take semiconductor laser and electric contact to the degree of the above-mentioned die bond, bonding of an up electrode and the drive circuit wiring is carried out with the wires 23, such as Au and Pt. Then, can enclosure is performed if needed and it considers as the finished product of semiconductor laser. Formation of the above-mentioned n type electrode 9, the nickel layer 10, and the solder layer 11 and junction to a heat sink 21 are explained. The composition of this portion is shown in drawing 3 .
[0029] In order that n type electrode 9 formed in the rear face of the n-GaAs substrate 1 may form an ohmic electrode, Au-Zn/Au, Cr/Au, Ti/Pt/Au, Au-germanium/nickel/Au, Au-Sn/Au, etc. and these alloy cascade screens are used as an electrode material. This is formed in the rear face of the n-GaAs substrate 1 by predetermined thickness by the electron beam evaporation which is a vacuum deposition method, resistance heating vacuum evaporationo, the spatter, etc.
[0030] Next, the nickel layer 10 is formed on n type electrode 9 by the same method. Then, the alloy which contains Sn, such as Au-Sn and Pb-Sn, as a solder layer 11 is formed on the nickel layer 10. About the formation method of a solder layer, it mentions later. Thus, the solder layer 11 containing 10/of produced 9/nickel layers Sn of electrodes is put on the heat sink 21 which gave metal plating 21a, such as nickel and Au, pressurization and heating are performed, and a semiconductor laser element is mounted on a heat sink 21 by fusing the solder layer 11 and cooling.
[0031] Although there are Au-Sn, Au-Si, In, In-Pb, Pb-Sn, Au-Pb, Au-germanium, etc. in solder material, the strong junction of a bond strength with sufficient wettability is obtained by soldering by carrying out the laminating of the solder and nickel containing Sn, such as Au-Sn and Pb-Sn. It is effective when Au-Sn is especially used for solder material. The duty of the nickel layer 10 has solder material, the role of the barrier electrode from which it is made for an electrode not to start counter diffusion, and the duty that is spread in a solder layer and improves the wettability of solder. With a GaAs semiconductor, using Au for the best layer of an electrode in many cases, Au is diffused at low temperature in the solder layer which is activity and will connect and to carry out, and the stability of contact becomes bad. For this reason, the barrier electrode is required, and when especially an electrode is the alloy of Au and Au, it is effective.
[0032] At least 200A of thickness of nickel as a barrier electrode is required. Less than [this], it becomes an island-like film and the duty of a barrier metal is not achieved. nickel thickness dependency of the intensity of the glue line at the time of

having formed 1000A of Au-germanium electrodes to the 0.5mmx0.5mm n-GaAs substrate, carrying out the laminating of the nickel/Au-Sn (Au and Sn being the thing of eutectic composition) on it, mounting in drawing 4 , and carrying out a vibration test to it is shown. This vibration test is JIS. It carried out on C7022A-10, Conditions D, the vibration frequency range of 10-2000Hz, acceleration 20G, direction 3 direction, and the conditions for time 48 minutes. In addition, the thickness of the Au-Sn solder layer 11 presupposed that it is fixed 1.5 micrometers.
[0033] The bond strength is large as the thickness of the nickel layer 10 becomes thick, and there is no difference in intensity at 1000A or more of thickness. In 1000A or more of thickness, since a substrate breaks during an examination, it is thought that intensity is more than this. Moreover, peeling arises [thickness] in 200A and sufficient bond strength is not obtained. If there are 500 or more gves of bond strengths, there is intensity of enough and it is necessary to bear various reliability trials, to accumulate and to make nickel thickness into 500A or more.
[0034] Next, how to form the solder layer 11 is explained. It tried to carry out the laminating of the component of alloys, such as Au-Sn, and to create it on the occasion of formation of the solder layer 11. In this case, the design of a composition ratio can be performed freely and management of vacuum evaporationo material is also easy for it. However, when the thickness of each class differs in this, it becomes a composition gap immediately. Usually, as for the composition ratio of solder, it is common to use eutectic composition, and the melting point becomes high when a composition gap is caused. Thus, if the melting point changes, you have to change the conditions of mounting into whenever [the]. If it carries out on the same conditions, even if solder material will not melt or it will melt, the stable adhesion intensity is no longer obtained after mounting, without fully melting.
[0035] Then, it examined forming alloys, such as Au-Sn, Pb-Sn, In, In-Pb, Au-Si, and Au-Pb, by the vapor growth as a solder layer 11. That is, the solder layer 11 is formed by the physical vapor growth which made the above-mentioned alloy the source of vacuum evaporationo. Here, a physical vapor growth calls it Physical Vapor Deposition (PVD), does not use a chemical reaction, but is the method of forming a thin film using a physical change, and has vacuum evaporationo, a spatter, ion plating, etc. If a physical vapor growth is put in another way, the material itself formed on a substrate will reach a substrate in the state of a steam or a cluster, and a thin film and a bird clapper will be said. On the other hand, as a method using the chemical reaction, there is the ChemicalVapor Deposition (CVD) method, this carries out the decomposition reaction of the raw material using energy, such as heat, plasma, and light, into a gaseous phase, it becomes a thin film using a chemical reaction, and, as for PVD, the principles of membrane formation differ.
[0036] Thus, by forming the solder layer 11, even if metaphor thickness varies, there is always almost no change of the melting point, and the above problems were able to be solved. As the membrane formation method by the vapor growth, electron beam evaporation, resistance heating vacuum evaporationo, a spatter, etc. can be used. Since some raw materials and composition ratios shift according to the difference of the vapor pressure of an alloy in electron beam evaporation and resistance heating vacuum evaporationo among these, it is desirable to use a spatter as the membrane formation method. In addition, since a composition ratio is decided by vapor pressure even if there will be no change of a raw material and a composition ratio and it will not carry out the vacuum evaporationo of all the raw materials, if most raw materials have been flown altogether when electron beam evaporation and resistance heating vacuum evaporationo are used, membranous composition ratios do not differ for every batch.
[0037] Although there was a problem that the upheaval object by superfluous solder might sometimes hide to a luminous layer, and served as hindrance of an optical output in the conventional thing which used the forming pellet as a solder layer As mentioned above, by making the solder layer 11 into the thin film by gaseous layer growth, the flash of the solder more than required was lost and the strong junction of the adhesion intensity obtained and stabilized of the solder layer of the good composition ratio of repeatability was attained.
[0038] Next, the thickness of the above-mentioned solder layer 11 is explained. Although the flash of the solder more than required was lost by making a solder layer into the thin film by gaseous layer growth, when carrying out the laminating of two or more semiconductor laser elements as mentioned above and solder layer thickness is thick, there is a problem of covering a luminous layer by the flash of solder. Moreover, when soldering the electrode of the side near a luminous layer, in [the case like the example 2 of creation mentioned later], the same problem occurs. On the contrary, when a solder layer is thin, there is a problem that adhesion intensity is weak.
[0039] The solder layer thickness when mounting a 0.5mmx0.5mm semiconductor laser element in the gold-plated copper heat sink at drawing 5 and the relation of adhesion intensity are shown. Adhesion intensity is so strong that the thickness of a solder layer becomes thick, and does not have a strong difference at 1 micrometers or more. By 1 micrometers or more, since a substrate breaks, thickness is considered that there is intensity more than this. If there are 500 or more gves of bond strengths, it turns out that there is intensity of enough and various reliability trials can be borne. Therefore, there should just be 3000A or more of thickness of a solder layer.
[0040] Solder layer thickness has the surface roughness and relation of an adhesion side, and used Ra=1000A for this measurement this time. Generally, the thickness of a solder layer was understood that it needs to be thicker than surface roughness and about 3 times [of surface roughness] thickness is more nearly required than this result. The surface roughness Ra=500-2500A thing of the adhesion side of the stem used for mounting is used. Since, as for the surface roughness of a stem, the 1000A thing is usually used, solder layer thickness is at least 3000A or more need, and its 5000A or more is desirably good.
[0041] Although the thickness of a solder layer has so strong that it becomes thick adhesion intensity, if it becomes thick, as for a solder layer, ****** will pose a problem. When more than one are mounted especially, the flash of a solder layer will cover a luminous layer. Furthermore, if thickness becomes thick, membrane formation time will also become long, and problems, like the amount of vacuum evaporationo material also increases arise. By Atsushi whose solder layer is 1 micrometer, although there is almost nothing, the flash of a solder layer will be protruded in addition to the rear face of a chip, if it becomes the thickness beyond it. When solder layer thickness was made larger than 3 micrometers, solder was attached to the luminescence side side, and in 4 micrometers or more, time generated the luminous layer with the wrap. Therefore, the thickness of a solder layer has good 3 micrometers or less.
[0042] Therefore, strong junction of adhesion intensity is attained by setting thickness of the solder layer 11 to 0.3-3 micrometers. Moreover, the optical output by which adhesion intensity was stabilized strongly is obtained, without the solder

of the laminating section covering a luminous layer, when carrying out the laminating of two or more semiconductor laser. The example of creation of the semiconductor device using the above-mentioned solder layer 11 is shown.

(Example 1 of creation) The GaAs/AlGaAs system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the n type electrode side. At this time, the three-piece laminating of the semiconductor laser element was carried out. 1000A of Au88wt%-Gewt12% was formed as an n type electrode, and 1000A and 1 micrometer of Au-Sn solder were prepared for nickel on it. At this time, Au-germanium/nickel formed membranes using E.B. vacuum evaporationo, and the solder layer formed membranes by the spatter. Size of a semiconductor laser element was set to 500x600x110 micrometers. This element was placed in piles on [three] the copper heat sink which gold-plated, and it mounted by the heating temperature of 340 degrees C, and 60g of pressurization loads. The mounted element does not have the flash of a solder layer, either and solder did not cover a luminous layer. In this element, when three directions were performed for the variable frequency of 10-2000Hz, 20 G/sec2, and 48 minutes, it was changeless in any way examination before. When the bond strength of this element was measured with the SHIEA circuit tester, the intensity of 1 or more kgves was obtained.

(Example 2 of creation) The InGaP-InGaAlP system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the p type electrode side. Ti1000A, Pt2000A, and Au3000A were formed as a p type electrode, respectively, and 800A and 0.8 micrometers of Au-Sn solder were prepared for nickel on it. E.B. vacuum evaporationo was used for membrane formation at this time. Size of a semiconductor laser element was set to 600x700x110 micrometers. Although p type electrode was soldered, the good optical output was obtained without a solder layer covering a barrier layer. Furthermore, adhesion intensity also acquired the value of 1 or more kgves, and the stable contact was obtained.

(Example 3 of creation) The GaAs field-effect transistor element was produced on the half-insulation GaAs substrate, and it soldered to the printed circuit board which gold-plated. 2 micrometers of Au-Sn solder were prepared in the substrate rear face. At this time, membranes were formed by the spatter. Element size is 500x600x180 micrometers. This element was mounted by the heating temperature of 360 degrees C, and 100g of pressurization loads. When the bond strength of this element was measured with the SHIEA circuit tester, the intensity of 1 or more kgves was obtained.

[0043] Next, the cementing material using solder is explained. Although it is effective to enlarge the set points, such as virtual junction temperature, a pressurization pressure at the time of junction, and pressurization time, in order to raise wettability or a bonding strength when joining a semiconductor laser element which was mentioned above to a heat sink, since As in GaAs used as a material of a semiconductor laser element has low sublimation temperature, a high virtual junction temperature increases the heat damage done to an element. Moreover, the mechanical damage which also gives a high pressurization pressure and long pressurization time to a luminous layer is increased.

[0044] Therefore, in junction of a semiconductor laser element, it is necessary to select the cementing material which makes virtual junction temperature low and mitigates the heat damage to a semiconductor laser element. this invention person etc. found out that the melting point lower than an Au80wt%-Sn20wt% pellet was acquired, when it considered as the laminated structure of nickel/(Au80wt%-Sn20wt%), using Au-Sn system solder as a solder layer 11, as a result of examining many things for the above-mentioned point. nickel diffuses this in an Au-Sn layer, and depends it on making a Au-Sn-nickel alloy.

[0045] Based on this, nickel thickness was changed, nickel concentration which carries out thermal diffusion to Au80wt%-Sn20wt% Naka was changed, and the state diagram was created. The result is shown in drawing 6 . In this drawing, L and S show the liquid phase and solid phase, respectively, and alpha and beta show the solid solution of Au-Sn-nickel, respectively. Therefore, it expresses that (L+alpha) and (L+beta) are the mixed state of the liquid phase and solid phase, respectively. The thickness of nickel when setting Au80wt%-Sn20wt% thickness to 1.5 micrometers in nickel/(Au80wt%-Sn20wt%) layer structure is shown in an upper horizontal axis.

[0046] From this state diagram, a (Au80wt%-Sn20wt%)-nickel alloy becomes lower than the melting point of an Au80wt%-Sn20wt% pellet, when the amount of nickel increases, and when the composition ratio (weight ratio of nickel to the total weight of a cementing material) of nickel is made into 1.3wt(s)%, about 10 degrees C of melting points become low. Furthermore, the amount of nickel is increased, when it considers as about 3wt%, the melting point becomes low most, and compared with an Au80wt%-Sn20wt% pellet, it falls by 25 degrees C or more. Therefore, virtual junction temperature can be reduced by 25 degrees C or more to having joined by the melting point of a conventional Au80wt%-Sn20wt% pellet, and the heat damage to an element can be reduced.

[0047] in addition -- what [not only] nickel diffused the above-mentioned effect and the effect mentioned later in the Au-Sn layer, it depends on making a Au-Sn-nickel alloy, and was made into the laminated structure of nickel/(Au80wt%-Sn20wt%) but a (Au80wt%-Sn20wt%)-nickel alloy layer -- also carrying out -- it can obtain similarly The composition ratio of nickel of Au80wt%-Sn20wt% Naka and the relation of a bonding strength are shown in drawing 7 . This drawing shows being saturated with composition beyond 2.5wt%, although it becomes strong as the composition ratio of a bonding strength of nickel increases. In the experiment, it is checked that intensity is measured to 9.5wt% and there is sufficient intensity.

[0048] although nickel composition ratio exfoliates in respect of adhesion of a heat sink and solder with the 0.7wt(s)% conventional structure in a bonding-strength examination -- nickel composition ratio -- by the plane of composition, it does not exfoliate but the element section joined is destroyed more than at 1.3wt% Since it turns out that sufficiently various kinds of reliability trials can be borne if a bonding strength is 500 or more gves, the bonding strength stabilized when nickel composition ratio was more than 1.3wt% is obtained.

[0049] In addition, in drawing 7 , a 50g pressurization load is added, in the case of beyond 2.5wt%, it does not pressurize, and 1.7wt% of case joins only by the self-weight of an element nickel composition ratio 1.3wt(s)%. Therefore, bonding strength only with the sufficient self-weight of an element can be obtained by making nickel composition ratio more than 2.5wt%. From these results, the melting point of solder falls, a bonding strength is still stronger and by adding nickel to Au80wt%-Sn20wt% Naka shows a bird clapper. The composition ratio of nickel is good, and if it takes wettability and a bonding strength into consideration, more than its 1.3wt% is desirable. [1wt% to 10wt(s)% to which the melting point falls by 10 degrees C or more of] the composition ratio of nickel since the low melting point is acquired most and the composition after solder solidification is kept uniform in the long run -- 3wt(s)% in a 3 yuan system -- especially 2wt(s)% to 5wt(s)% of order is desirable

[0050] In addition, if the composition ratio of nickel becomes 10% or more when nickel composition ratio is made to increase by thickening nickel thickness on Au-germanium, the intermetallic compound of Sn-nickel is generated, and since the intermetallic compound is an insulator, the resistance of a joint will become high. Therefore, if the increase in resistance of a joint is taken into consideration, it is desirable to make the composition ratio of nickel into less than 10%.
[0051] Thus, a cementing material is the solder material which contains nickel of a constant rate in an Au-Sn eutectic solder, and when a plinth front face was Au layer, it came to be able to do by stabilizing the strong junction of a bond strength with sufficient wettability, when joining a semiconductor laser element to a plinth etc. In addition, also in the thing of the laminated structure of above-mentioned nickel/(Au80wt%-Sn20wt%), it is desirable to make thickness of nickel into 500A or more, as mentioned above, and to set thickness of an Au-Sn alloy solder layer to 0.3-3 micrometers.
[0052] The example of creation using the above-mentioned cementing material is explained.
(Example 4 of creation) The GaAs/AlGaAs system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the n type electrode side. 0.1 micrometers was formed for Au88wt%-germanium12% as an n type electrode, and 0.1 micrometers and 1.5 micrometers of Au-Sn solder were prepared for nickel on it. At this time, (Au-germanium)/nickel formed membranes using E.B. vacuum evaporationo, and the solder layer formed membranes by the spatter. Size of a semiconductor laser element was set to 500x600x110 micrometers. This element was placed on the copper heat sink which gold-plated, and it mounted, without adding the heating temperature of 340 degrees C, and a pressurization load. In this element, when the vibration test of three directions was performed for variable frequency [of 10-2000Hz], and 20 G or 48 minutes, it was changeless in any way examination before. When the bonding strength of this element was measured by the circuit tester, the intensity of about 1kg was obtained. The composition ratio of the cementing material at this time was Au77.3wt%-Sn19.3wt%-nickel3.4wt%.
(Example 5 of creation) The InGaP-InGaAlP system semiconductor laser element was produced on the n-GaAs substrate, and it soldered on the copper heat sink which gold-plated the p type electrode side. As a p type electrode, 0.1 micrometers was formed for Ti, 0.2 micrometers and 0.3 micrometers of Au(s) were formed for Pt, and 0.1 micrometers and 1.0 micrometers of Au-Sn solder were prepared for nickel on it. E.B. vacuum evaporationo was used for membrane formation at this time. Size of a semiconductor laser element was set to 600x700x110 micrometers. Although p type electrode was soldered by the heating temperature of 340 degrees C, and 30g of pressurization loads, the good optical output was obtained without a solder layer covering a barrier layer. Furthermore, the bonding strength also acquired the value of 1 or more kgves, and the stable contact was obtained. The composition ratio of the cementing material at this time was Au76wt%-Sn19wt%-nickel5wt%.
(Example 6 of creation) n type electrode side of a top semiconductor laser element was soldered to the upper surface by the side of p type electrode of a semiconductor laser element, and it considered as the laminated structure. As a p type electrode, 0.04 micrometers and Pt layer were formed for Cr, and 0.5 micrometers was formed for 0.1 micrometers and Au layer. 0.1 micrometers of Au88wt%-Gewt12% were formed as an n type electrode, and 0.1 micrometers and 1.5 micrometers of Au-Sn solder were prepared for nickel on it. At this time, (Au-germanium)/nickel formed membranes using E.B. vacuum evaporationo, and the solder layer formed membranes by the spatter. Size of a semiconductor laser element was set to 600x700x110 micrometers. n type electrode was soldered on p type electrode by the heating temperature of 340 degrees C, and 30g of pressurization loads. When the bond strength was measured with the SHIEA circuit tester, the intensity of 500 or more kgves was obtained. At this time, the solder layer obtained the good optical output [be / nothing], alias a wrap, for the barrier layer. Moreover, the output was able to be increased by making a semiconductor laser element into a laminated structure. The composition ratio of the cementing material at this time was Au77.3wt%-Sn19.3wt%-nickel3.4wt%.
[0053] Although the heat sink which plated Au, nickel, etc. as a plinth was shown, you may make it solder a semiconductor device for plinths, such as Fe and Cu, in the above-mentioned various examples. Moreover, although the thing for a semiconductor laser element was explained as a semiconductor device, this invention is applicable also to other semiconductor devices. In this case, it is applicable also to what uses a short key electrode in addition to an ohmic electrode. As a material of this short key electrode, it can consider as aluminum, Pt, Au, Ta, Cr, W, Mo, Ti, Cu, Ag, and Ai-Si.
[0054] Moreover, this invention is applicable also to electric element, such as a chip resistor and a chip capacitor, in addition to a semiconductor device. Next, other above-mentioned examples of application of a Au-Sn-nickel cementing material are explained.
(Example 7 of creation) When the drive IC 30 of a liquid crystal display or electroluminescence (henceforth EL) display is mounted on a glass substrate 31 and it connects with a conductor (electrode) 32, there is a thing of composition of being shown in (a) shown in drawing 8 , (b), and (c). That for which (a) used the mounting pad 33 and the wire 34, the thing for which (b) used the bump 36, and (c) use the beam lead 37. the above-mentioned Au-Sn-nickel cementing material -- in (a), it is used for the cementing material of the mounting section 35 and the mounting pad 33 as the beam lead 37 as a bump 36 by (b) at (c)
[0055] Hereafter, the example which mounts drive IC 30 in an EL panel using the composition of (a) is explained. In order to produce an EL panel, first, on the glass substrate 31, as a transparent electrode, 0.1 micrometers was formed and ITO was processed on the stripe. Next, 1 micrometer of CaS:Eu was formed by the E.B. vacuum deposition as a luminous layer. Next, it is SiO2 as an insulating layer. 0.3 micrometers was formed by RF and P-CVD, subsequently 0.15 micrometers of aluminum were formed as a back plate 32, and patterning was performed to the predetermined pattern. Next, as the mounting pad 33 and an ejection pad of wiring, 0.1 micrometers of nickel were formed first, subsequently 0.5 micrometers of Au(s) were formed, and patterning was performed. Membrane formation was performed by the spatter. Finally, the glass substrate 31 was joined by the epoxy resin, the silicone oil was enclosed, the protective layer was formed, and it considered as the EL panel.
[0056] Subsequently, in order to join drive IC 30 to a glass substrate 31, 0.2 micrometers of nickel were formed at the rear face of drive IC 30, and, subsequently (Au80wt%-Sn20wt%), 2 micrometers formed membranes at it. All performed membrane formation by the spatter. This was joined to the mounting pad 35 in 350 degrees C and 80g of pressurization loads. On the other hand, the ejection pad of EL panel wiring and the ejection pad of drive IC 30 were wired using the Au wire 34. Thus, the drive IC 30 was mounted by the bonding strength stabilized on the glass substrate 31. The composition ratio of the cementing material at this time was Au76wt%-Sn19wt%-nickel5wt%.

(Example 8 of creation) To drawing 9 , it is SiNX. The example which joined the Si substrate 42 and the GaAs/AlGaAs system semiconductor laser element 40 which prepared the optical waveguide using the bump 44 is shown. The (Au78wt%-Sn19.5wt%)-nickel2.5wt% cementing material was used as a bump 44, four things of 40 micrometers of diameters of a bump were used, and the semiconductor laser element 40 was mounted in the Si substrate 42. The bump 44 formed on the Au pad 43 on the Si substrate 42. Thickness could be 0.1 micrometers, 0.02 micrometers, and 0.4 micrometers at the rear-face electrode 41 of the semiconductor laser element 40 using (Au-germanium)/nickel/Au, respectively. the semiconductor laser element 40 -- a bump 44 -- putting -- the substrate whole -- 360-degree C constant temperature -- it joined by performing a reflow in a layer Thus, the semiconductor laser element 40 was mounted on the Si substrate 42.

[Translation done.]

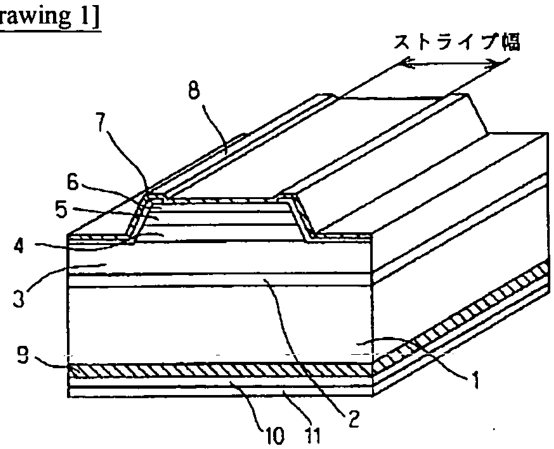
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective diagram of a semiconductor laser element showing the example at the time of applying this invention to a semiconductor laser element.
[Drawing 2] It is the perspective diagram showing the state where die bond of the semiconductor laser element was carried out to the heat sink.
[Drawing 3] It is the ** type view showing the composition when joining n type electrode, nickel layer, and the solder layer which are formed in the rear face of a n-GaAs substrate to plinths, such as a heat sink.
[Drawing 4] It is the property view showing nickel thickness at the time of carrying out a vibration test, and the relation of a bond strength.
[Drawing 5] It is the graph which shows the relation between solder layer thickness and adhesion intensity.
[Drawing 6] It is drawing showing change of the melting point when changing nickel concentration which carries out thermal diffusion to Au80wt%-Sn20wt% Naka.
[Drawing 7] It is drawing showing the composition ratio of nickel of Au80wt%-Sn20wt% Naka, and the relation of a bonding strength.
[Drawing 8] It is drawing showing the composition which mounts the drive IC of display on a glass substrate.
[Drawing 9] SiNX It is drawing showing the composition which mounted the semiconductor laser element in Si substrate which prepared the optical waveguide.
[Description of Notations]
1 [-- A clad layer, 4 / -- A barrier layer, 6 / -- A p-GaAs layer, 7 / -- An insulator layer, 8 / -- p type electrode, 9 / -- n type electrode, 10 / -- nickel layer, 11 / -- A solder layer, 21 / -- Heat sink.] -- A n-GaAs substrate, 2 -- 3 A buffer layer, 5

[Translation done.]

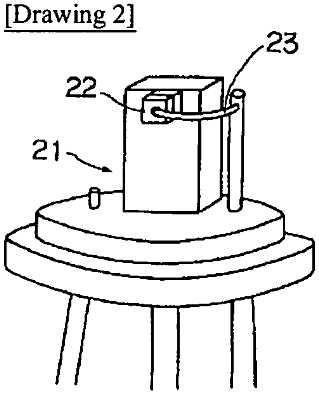
DRAWINGS

[Drawing 1]

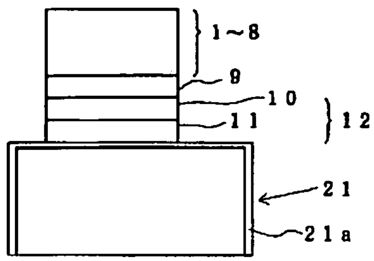


1	ｎ－ＧａＡｓ基板	8	Ｐ型電極
2	ｎ－ＧａＡｓバッファ層	9	ｎ型電極
3	ｎ－ＡｌＧａＡｓクラッド層	１０	Ｎｉ層
4	活性層	１１	はんだ層
5	Ｐ－ＡｌＧａＡｓクラッド層		
6	Ｐ－ＧａＡｓ層		
7	絶縁膜		

[Drawing 2]

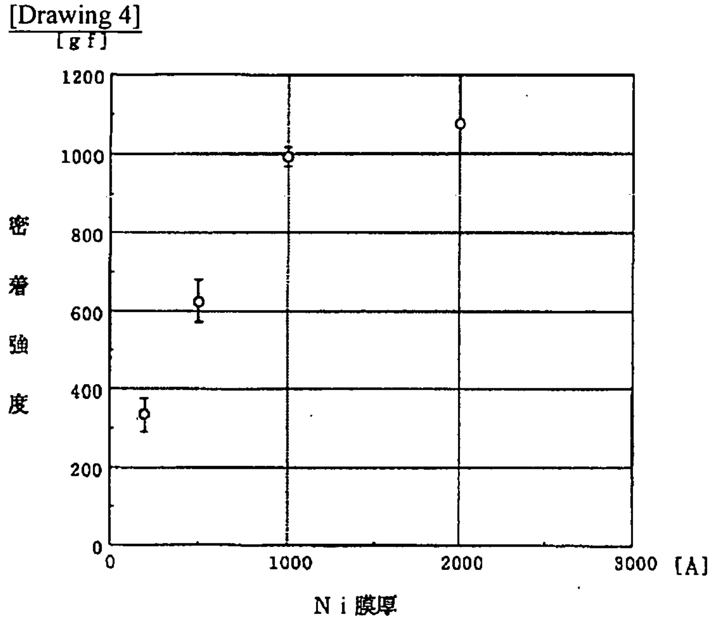


[Drawing 3]

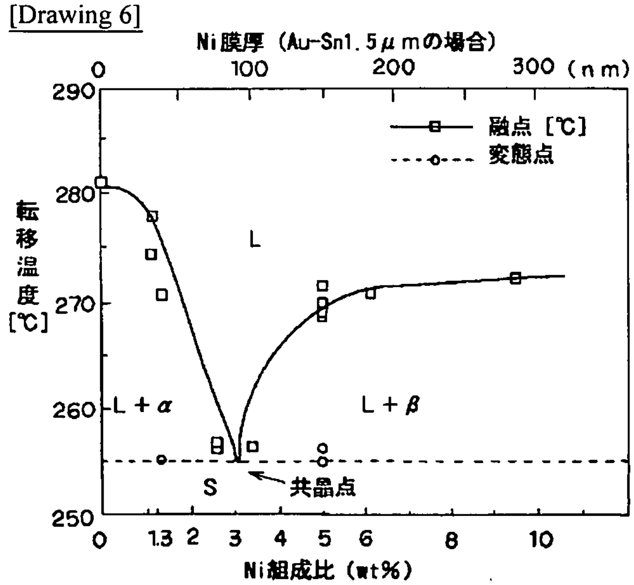


9 ：n型電極
10：Ni層
11：はんだ層
12：接合材料
21：ヒートシンク
21a：金メッキ

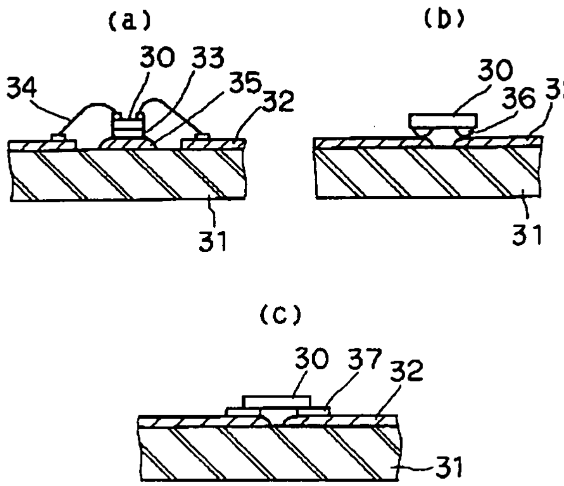
[Drawing 4]



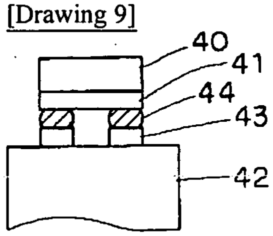
[Drawing 6]



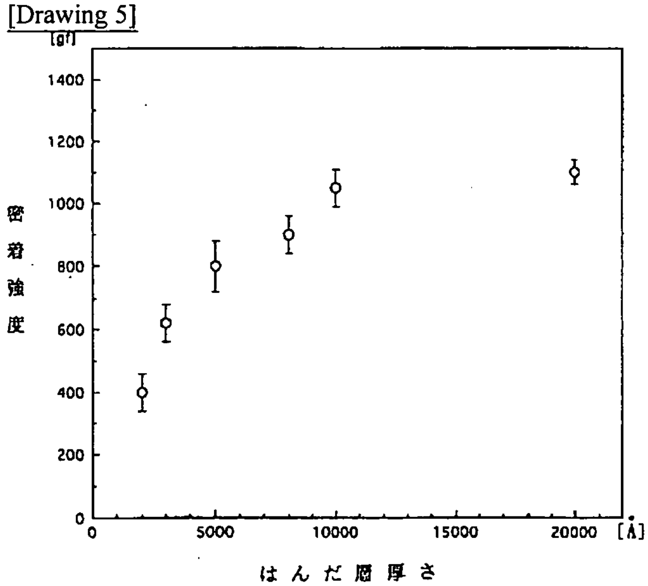
[Drawing 8]



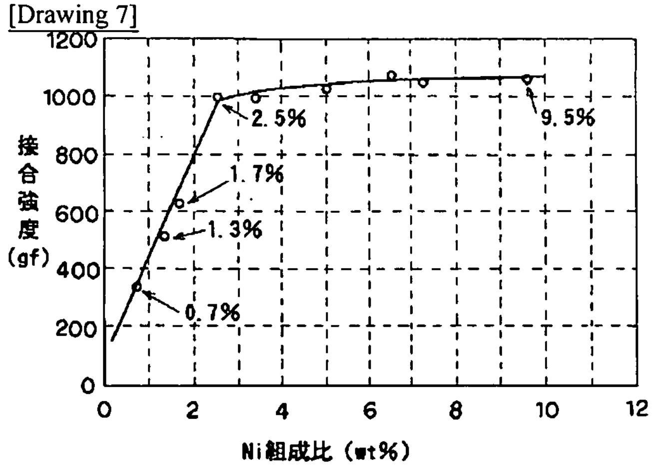
[Drawing 9]



[Drawing 5]



[Drawing 7]



[Translation done.]